THE GEORGE BLUMER

EDITION OF

BILLINGS FORCHHEIMER'S

THERAPEUSIS OF INTERNAL DISEASES

VOLUME I

THE GEORGE BLUMER
EDITION OF
BILLINGS-FORCHHEIMER'S
THERAPEUSIS
OF INTERNAL DISEASES

CARE AND MANAGEMENT OF MALADIES
AND AILMENTS OTHER THAN SURGICAL

VOLUME I

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PREFACE TO THE FOURTH EDITION

The Editor who assumes to revise a work planned by such masters of medicine as Frederick Forchheimer and Frank Billings has no enviable task. Nevertheless he is aided by the factor of time, for in no branch of applied science is progress more rapid than it is in the practice of medicine. In the years which have elapsed since the last revision of this work numerous discoveries have been made, and this statement is particularly true when one deals with the subject of applied therapeutics. In addition numerous discoveries have been made bearing upon the classification of disease, on its etiology, on its pathology, and it has been the aim of the Editor to incorporate these into the present edition.

The study of disease from the functional standpoint has progressed so rapidly and this study has thrown so much light into hitherto dark corners that a consideration of remedial agencies from this view of pathology is an urgent necessity in present day therapeutics.

The reader will find in the present edition a rearrangement of the infectious diseases, necessitated by added knowledge regarding etiology. A section on therapeutic technic has been added to the second volume, in order to emphasize the more technical aspects—paracentesis, venesection, transfusion, etc.—and the general principles underlying the administration of medicine by various routes.

The section on intoxications has been greatly expanded, and an attempt has been made to arrange it so that the various aspects of intoxication are discussed in the form in which they present themselves to the general practitioner. The sections dealing with diseases due to dietary deficiencies and anaphylaxis have been entirely revised and rearranged.

An entirely new section on occupational diseases, the importance of which has been emphasized by the numerous State Compensation Laws, has been written. The section on the diseases of the circulatory organs has been rearranged and almost entirely rewritten. New sections dealing with the treatment of the common affections of the eye, ear and skin have been introduced, and also chapters dealing with such minor surgical and gynecological infections as can be handled satisfactorily by the general practitioner.

The importance of a thorough knowledge of applied therapeutics is of such positive moment to the man in practice that the revision of this work becomes of importance to the entire profession. Under the able editorial supervision of Frederick Forchheimer and Frank Billings this work achieved a national acceptance and international recognition that has never been given to any other American work covering the same field.

In order to maintain the position of this work, the Editor has used his best endeavor to select authors for the new sections who are masters in their chosen fields, and, where the articles of previous authors have been rewritten by some one other than the original, the same care has been exercised

GEORGE BLUMER

PREFACE TO THE FIRST EDITION

This work was undertaken because it seemed that a presentation *in extenso* of the therapeusis of internal diseases might be valuable to all those engaged in the practice of medicine.

I venture to say that the subject of the treatment of internal diseases is fast becoming, if it has not already become, one of the most important subjects we have to deal with, either as practitioners or teachers. The reason for this is obvious. Not very long ago the basis of all therapy was empiricism and empiricism only. Then followed a period in which metaphysical reasoning replaced empiricism, giving rise to the development of schools and not infrequently of medical sects, some of which still survive even in this period of scientific enlightenment. It may be added that even now new sects are arising, and possibly will continue to arise as long as human credulity survives.

Following this metaphysical period we meet with a most interesting therapeutical manifestation, that of medical nihilism. That great clinician, Skoda, for instance, believed so little in drugs that he treated all his typhoid fever patients by giving them small doses of a weak solution of alum. But, on the other hand, he was the first to place auscultation and percussion upon a physical basis. For him, then, there was no science of therapeusis, although there was science in percussion and auscultation. The nihilistic tendency still has adherents, although their number is small and constantly growing smaller.

Comparatively recently laboratories began to play a very important rôle. Physiology, pathology, chemistry, microscopy, and physics as applied to medicine were being developed, and theoretical therapeutic problems were being solved by laboratory methods, which in turn of themselves have become a fetish.

Moreover, there was more careful and accurate observation of disease. But the most conspicuous and important contribution to our therapeutic knowledge in this connection consisted in the acceptance of physiological effects of drugs and their determination. With this to go upon, medical therapeusis received a great and fruitful impetus. It may be safely said that this was the beginning of scientific medical therapeusis, for the first time it was possible to come to a therapeutic conclusion which was scientific in a measure, the result of observation plus reasoning.

If we now come to our present day we see a remarkable state of affairs. Not only have the therapeutics of to-day been developed beyond anything

that could have been hoped for twenty five years ago, but vistas are being opened which promise advances hoped for only in some dim future state. And yet, if we reflect, the time had come for great and radical advances in this line. The branches of science already mentioned upon which treatment is based had developed to a degree that seemed incredible, and each advance was eagerly seized upon by those who were prepared and ready to apply this development.

Therapeutics, therefore, is beginning to take a place with the other branches of medicine, in as far as its scientific status is concerned. That therapeutics will ever be a pure science seems, at present, out of the question. But the fact that it is what it has developed to be leads us to believe that it is as yet in its infancy.

The great advances that can be recorded in our period are found in prophylaxis and causal or specific therapy.

In prophylaxis, especially in infectious diseases, results are obtained which a short time ago would have been considered impossible. The greatest enthusiast would have deemed it incredible, for instance, that the day would ever come when Havana would quarantine against Key West in yellow fever. Many other instances could be cited in which modern prophylaxis has prevented the spread of disease and the development of epidemics. Indeed, this is now so common that very little ado is made of it. Much more remarkable, however, is the rendering sanitary large tracts of land which were uninhabitable before, thus giving more and better chances for life and health to more human beings.

As wonderful as this seems, the greatest advance made in therapeusis has been in causal therapy. We are no longer solely guided in the use of drugs by their physiological effects, but demand effects upon pathological states and conditions in this way coming nearer the cause of things and frequently removing it. The treatment of specific causes by specific methods of treatment is especially notable at the present time. Formerly there were two specifics mercury and quinia. At present there is a large number in infectious diseases, in the form of vaccination with virus from animals less susceptible than man, by vaccinating with small numbers of bacteria from violent cultures, by injecting dead bacilli and bacterial products and sera. Relatively still in their infancy, these modes of treatment have already changed the therapeusis of infectious diseases.

Furthermore, there has taken place a revival in the use of physical measures, which have proved themselves very valuable in the light thrown upon them by modern modes of investigation. I refer here to hydrotherapy, balneology, massage and gymnastics, mechanotherapy, electrotherapy light therapy, Roentgen ray therapy. Nutrition and dietetics have been put upon a scientific basis, and psychotherapy is being applied in a rational way for definite purposes. One of the recent additions to

our knowledge, and one which promises much for therapeusis, is physical chemistry. By adding to this list of subjects toxicology, organotherapy, and climatology we have an enumeration of the means applied to the treatment of disease, except of that due to direct medication. If we except this, which it seemed to me required no special mention or space, as it is discussed and described throughout the book, we have subjects that have a broad general bearing so that I have grouped them together under the heading of General Therapy and given the whole of the first volume to their discussion. As far as I know this was first attempted in the 'Handbuch der allgemeinen Therapie,' edited by H. von Ziemssen in 1883. It would seem to me that the grouping of these subjects is invaluable as forming a foundation upon which the whole of therapeusis may be built up. Not alone is this the case, but they serve to bind the various subjects together. The practical value of this division lies in the fact that the general therapeutic measures are fully described and reference can be made to them.

Having then made one division of the whole subject we follow the Germans and make a second, that of special therapy, which includes the treatment of all diseases which are classified as belonging to internal medicine. Here it is not only the treatment of a special disease but also the special treatment of a special patient which makes the subject one beset with great difficulties as well as of transcendent interest. As a result of the complexity of the subject it will be readily seen that there is no branch of medicine which may not have some bearing on special treatment; this applies to anatomy, physiology, physics, chemistry, pathology, symptomatology, pharmacology, to mention only the most important ones. Moreover, the mutual relations of internal medicine to other departments such as surgery and the various specialties must be considered. In these days of multiplication of specialties internal medicine itself may be overlooked, so that only a part of the condition and not the whole is treated. The fact that a prescription is the last act in a long process of reasoning should always be borne in mind.

The prescription should not be written until everything which bears upon the condition of the patient has been considered. It is necessary to make a diagnosis which must include pathology and pathogenesis, this especially for causal treatment. The symptomatology must be carefully investigated, as in many instances the relief of symptoms is all that can be done or all that should be done. The therapeutic measures to be taken should then be determined; if drugs, those that fulfill the indications should be chosen. In every case the individual characteristics of the patient should be studied. When all this has been done the patient is ready for his prescription.

It is in this spirit that the various subjects comprising the work have been treated by the contributors. Everything that has bearing upon

that could have been hoped for twenty five years ago, but vistas are being opened which promise advances hoped for only in some dim future state And yet, if we reflect, the time had come for great and radical advances in this line The branches of science already mentioned upon which treatment is based had developed to a degree that seemed incredible, and each advance was eagerly seized upon by those who were prepared and ready to apply this development

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It is in this spirit that the various subjects comprising the work have been treated by the contributors. Everything that has bearing upon

therapy is considered, and, as the subjects differ so much, it will readily be seen that uniformity could not be attained Under all circumstances the primary object is to illuminate the subject of treatment and to give all that is known or worth knowing, and the work is primarily written for all those who wish to be informed of the details of treatment of disease, even the smallest ones

Prescriptions are given in the text when found necessary, first, on account of showing how the drug is best administered, secondly, the quantity of drug to be given and at what intervals The days of formulæ are not over, and all of us it must be confessed, like to employ a formula which has been recommended by a competent observer All doses of drugs, as well as all prescriptions, are given in apothecary's weight and in the metric system

The authors who have honored me by writing were chosen because I considered them thoroughly equipped and best able to write upon the subjects assigned to them Their names and their reputations are a guarantee of the quality of their work

I wish to express my especial thanks to Drs William Wherry and Joseph C Collins for assistance given in the arrangement of these subjects

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PRINCIPLES OF GENERAL THERAPY

CHAPTER I

SOME PHYSICOCHEMICAL PRINCIPLES IN THERAPY

MARTIN H FISCHER

REVISED BY WALTER W PALMER

It is safe to say that the ultimate test of every teaching in medicine and surgery lies in prognosis and therapy A correct prognosis means that we understand the course of the diseased process with which we are dealing, it is favorable if we are able to retard, stop, or reverse the series of physical or chemical changes that have placed a patient in the diseased state in which we find him, or unfavorable if we are unable to do this A successful therapy means that we not only understand this matter of prognosis but also that we have at our disposal appropriate measures by which we may retard, stop or reverse the course of the diseased process

We like to believe and aim to make our therapy rational Through the ages there have come down to us the results of the observations of many men who seeing that a diseased process was modified, say through the laying on of hands or through the consumption of sea weed have recommended such procedures subsequently to patients similarly afflicted Such therapy is not rational but empirical But just because it is empirical it is not to be despised A therapeutic procedure that brings good results is never to be despised it usually merely represents the phenomenon of a practical result that has been attained sooner than the interpretation of the mechanism of this result. So to return to our illustration we recognize in the laying on of hands the psychotherapy of to-day and in the administration of sea weed the consumption of iodids

But, while we may not despise any good therapeutic procedure just because it is empirical, we have every reason to despise the modern therapist who employs the empirical method where a rational one is at hand or who employs the empirical method in the hope of winning thereby new and valuable means of combating disease. Such may result, but the methods employed are uneconomical. So, instead of exhausting a pharmacopeia and the time of a hundred workers in trying to find a curative agent for myxedema, it is better to understand the physiology and the pathological physiology of the thyroid gland, and then the beneficent effects of the administration of thyroid gland can almost be told in advance.

What we have just illustrated by reference to myxedema holds true for all our therapy, whether we would practice, as far as possible, a rational therapy now, or whether we are interested in the advancement of this branch of medicine. We ignore the fact too completely in medicine that a rational therapy can be built only upon a rational pathology, and that a rational pathology is impossible without a knowledge of physiology. Physiology, which is to-day a mere gargoyle, will yet become the keystone of a modern medicine.

When we have realized these simple truths for the good of the development of a scientific therapy, we need next to appreciate the fact that the unit for consideration in physiology, and so in pathology and therapy, is the cell. As we are practical men in medicine we are likely to lose sight of this fact or to take exception to it, and yet the most practical man, as we shall see, will heed the physiology of the cell most. The reasons for this are obvious.

When a man falls ill, be the cause what it may, he does not do this all over. Only individual parts of the body may be affected or some parts of the body are affected sooner or more intensely than others. So a man may be poisoned by an infection and this poison may kill his heart muscle cells, in consequence of which the rest of his body cells then die, for because the heart has failed no oxygen is supplied the remaining tissues of the body. Or through a rapid loss of carbon dioxid from the body, the cells governing respiration in the medulla are no longer excited to activity, and so the respiratory movements cease, the blood is no longer oxygenated, and the rest of the body cells die because they are deprived of oxygen. We could give similar illustrations for the liver, or the kidneys, or the thyroid, or any other organ of the body. It is the injury to certain cells in each case that furnishes the characteristic signs of any pathological entity, and if this injury or the death of these cells removes a condition upon which the life of cells in other parts of the body depends, then these too die. And so the whole body may die. The individual cells of a multicellular organism are like the ordinary ameba, only in the complex organism certain functions (possessed also by the ameba) have been especially developed and predominantly assumed by

groups of these cells These functions have come to be of particular importance only because they have this character of exercising a function upon the proper execution of which the remaining cells of the complex body are dependent (respiration, circulation)

In a complex organism we may therefore distinguish between a *general* physiology (common to all cells) and an *organ* or *special* physiology When we remember that such organ or special physiology scarcely ever represents more than an unusually prominent development of some function of *general* physiology the necessity and the predominant importance of the general physiology of the cell become manifest

These remarks will serve to show why, in our discussion of certain therapeutic principles that are of service in daily practice, we find ourselves beginning with a discussion of the behavior of the individual cell To be familiar with the effect of various external conditions upon the general behavior of the individual cell is to be familiar with the behavior of these same conditions upon groups of cells, and if such groups of cells (an organ) are part of and determine the behavior of yet other groups of cells in a complex organism to be familiar with the action of these external conditions upon the individual cell is to be familiar with their action upon the organism as a whole

Hence the importance and our interest in the physicochemical constitution of the individual cell An understanding of the most specialized therapeutic procedure is almost invariably dependent upon such a knowledge of the cell

So we shall find the behavior of arsphenamine to be but a brilliant illustration of the way in which a therapeutic agent distributes itself unequally between two cells (spirochete and body cell) the action of the cathartic salts but the therapeutic expression of the general effects of such salts upon all plant and animal protoplasm

THE GENERAL CONSTITUTION OF LIVING MATTER

The living matter of which all cells are composed needs from a therapeutic standpoint to be considered from the same viewpoint as its physiology, namely, from a purely physicochemical one Ultimate principles of therapy must be physicochemical in character

In our special discussion we shall deal but little with the purely chemical aspects of the constitution of living matter It is enough for us to remember that the various chemical constituents of the living cells are easily grouped under the general headings of the proteins the carbohydrate the fats the salts and water But the biological significance of the purely chemical attributes of these classes of compounds seems at the

present time in our scientific progress to stand largely behind that of certain physicochemical characteristics possessed by these same substances, and so we find it convenient to regroup these chemical entities under the headings of *the colloids*, *the crystalloids*, *and water*. We will consider these seriatim, for in a correct understanding of their physicochemical behavior are concealed the principles that govern much of our modern therapy.

The Colloids.—The bulk of living matter is made up of colloidal material. It will not surprise us, therefore, to discover that the behavior of colloidal material is identical with much that we consider characteristic of living matter.

It is now more than fifty years since Thomas Graham recognized that different chemical substances differ greatly in the rate with which they diffuse through solvents of various kinds. On the basis of this observation he made a distinction between those which diffuse slowly and those which diffuse very rapidly. As the former are for the most part amorphous and since ordinary glue is an example of this class, he called them colloids. The group that diffuses readily he called crystalloids, for such beautiful crystalline substances as cane sugar, ordinary salt, and urea are found in it.

Since Graham's studies, we have become familiar with further characteristics of colloids and crystalloids. Crystalloids are ordinarily stated to form true solutions. This colloids do not—they form pseudosolutions, that is to say, they simply remain suspended in the solvent. Colloidal solutions are, therefore, not homogeneous but heterogeneous, in their make-up.

Solutions of crystalloids show an osmotic pressure which is proportional to the number of particles of dissolved substance in the unit volume of the solvent. Upon this fact and the minuteness of the dissolved particles depends the diffusibility of the crystalloids. The most typical colloids, on the other hand, show practically no osmotic pressure, and correspondingly do not diffuse at all.

The enormous differences in osmotic pressure between crystalloids and colloids correspond to similar differences in the molecular weight of the substances composing the two groups. The molecular weight of the most pronouncedly colloidal bodies may be measured in thousands, while two or three hundred covers the weight of crystalloids, even when very complex organic compounds are concerned. The table on page 7 taken from Rudolf Hober shows this very well. The figures refer to 10 per cent solutions of the various substances.

Crystalloids can, moreover, diffuse uninterruptedly through colloidal membranes, such as animal bladders, intestines, sheets of agar agar or gelatin. Colloids are for the most part unable to do this. Upon this fact is based the principle of dialysis, in which crystalloids are separated

COLLOIDS AND CRYSTALLOIDS

Substance	Molecular Weight	Osmotic Pressure in Atmospheres	Depression of Freezing Point
Methyl alcohol	32	70.00	5.781
Urea	60	37.34	3.084
Glucose	180	12.43	1.027
Cane sugar	342	6.54	0.540
Albumose	2 400	0.93	0.078
Albumin	13 000	0.17	0.01[illegible]

from colloids by placing the mixture in a tube of parchment or an animal bladder and hanging the whole in water or some other solvent. The crystalloids diffuse out, leaving the colloids behind.

It must be stated, at once, however, that between the two extremes of the typical colloids, and the typical crystalloids, there is found an infinite number of substances which lean more or less strongly toward one side or the other. It is possible, for example, to obtain in a crystalline form certain albumins which may ordinarily be taken to represent our most typical colloids. Egg albumen may be obtained in such a state, and the physiological chemist is rarely satisfied with a hemoglobin that is not beautifully crystalline. On the other hand comparatively simple bodies such as silicic or tungstic acid are found in the group of our most representative colloids. These few facts will suffice to show that no hard and fast line can be drawn between the colloids on the one hand and the crystalloids on the other.

It should be clearly understood that, while we speak of colloids and crystalloids and therefore are seemingly classifying substances, we ought really to speak only of the colloidal and the crystalloidal *state*. Our familiar use of the terms colloidal and crystalloid has grown out of the fact that certain chemical compounds are best known to us in the colloidal state, while others we see almost always in a crystalloidal state. As a matter of fact it is probably safe to assume that any substance may be obtained in a colloidal form, even those simplest and most typical crystalloids, the chlorids of the various metals. That many typical colloids may, on the other hand, be obtained in crystalline form is evidenced almost daily by the ever growing list of biological products long known to us only in the form of amorphous powders, mucilages and syrups which chemists are obtaining in crystalloidal form. These considerations are not without biological significance, for a chemical substance in a colloidal form may, and usually does, possess entirely different properties from the same chemical substance in a crystalloidal form.

A. A. Noyes distinguishes between those colloids which are viscous, gelatinizing and not readily coagulated by salts, and those which are non-viscous, non-gelatinizing and readily coagulated by salts. To the

former of these groups belongs, for example, a solution of gelatin, albumin, globulin, glue, or dextrin, while in the latter might be mentioned the colloidal solutions of ferric hydroxid, aluminium hydroxid, various metallic sulphids and hemoglobin Perrin distinguishes between those colloids which in the solid state are rich in water and those which are poor The former of these Perrin designates as hydrophilic colloids, for the latter the name hydrophobic colloids has been suggested For the purposes of biology these terms are excellent, and in large part adequate For the purposes of physical chemistry in general they have the drawback of not being sufficiently broad Water is not the only solvent that may form the base of a colloidal solution To meet this objection Herbert Freundlich has proposed the name lyophilic colloids for those which show an intimate relationship to their solvent, while those which do not do this are called lyophobic

Wolfgang Ostwald who has taken a valuable step forward in the proper classification of the various colloids, distinguishes between the emulsion colloids and the suspension colloids the former of which represent colloidal solutions formed through mixture of two liquid phases, the latter through mixture of a solid with a liquid phase A separation of the two phases is difficult to obtain in the emulsion colloids, which correspond it will be seen with Noyes's first group and Perrin's hydrophilic colloids while the ready separation of the phases in Ostwald's second group brings to mind Noyes's second group, and the hydrophobic colloids

When we recall that the hydrophilic colloids which have thus far been accorded most study—gelatin, dextrin, starch glue, vegetable fibers, albumin, gums—are for the most part, derived from biological sources, their probable importance to the living animal or plant must at once be suspected Not only is the chief mass of the living organism built up of colloidal material but most of it belongs in the hydrophilic group We shall not be surprised in consequence to find that those physicochemical characteristics which make for the division of all colloids into two great classes will show themselves of importance in determining the biological behavior of the tissues

Recently, Loeb has contributed to our understanding of the colloidal behavior of proteins most valuable and interesting information He has shown that proteins may be looked upon as amphoteric electrolytes, capable of combining stoichiometrically with acids and alkalis to form salts, depending on the hydrogen ion concentration of the protein solution These protein salts are strongly hydrolyzed In this respect, the chemistry of protein does not differ from the chemistry of crystalloids On account of the large size of the protein ion and molecule, diffusion through membranes is difficult, while the reverse is true of the small crystalloid ions Donnan has shown that when a membrane separates two solu

tions, one of which may contain a non-diffusible ion mixed with easily diffusible ions there is an uneven distribution of ions, such that the products of the ions on opposite sides are the same This unequal concentration of crystalloid ions on opposite sides of the membrane gives rise to potential differences Loeb has shown that when protein is the non-diffusible ion in the presence of easily diffusible crystalloid ions, the concentration of the latter is always greater within the protein solution than in the surrounding solution and explains in large measure the colloidal behavior of the protein solutions He has been able to calculate with considerable accuracy from Donnan's equilibrium equation the effects of electrolytes on osmotic pressure, swelling and viscosity of proteins

The importance of this conception of colloidal behavior cannot be overestimated It suggests new methods of approach to the study of such pathological processes as edema, in the hopes that a better understanding of the condition may lead to more rational therapy Use of the principles evolved should bring forth most interesting information in the fields of physiology bacteriology and immunology

The Crystalloids—The crystalloids may be divided into two great groups, the *electrolytes* and the *non electrolytes* We shall find that the characteristics that make such a division possible in the realm of pure physical chemistry also distinguish the biological behavior of these two groups from each other

Substances which when dissolved in water (and certain other solvents) conduct the electric current are known as *electrolytes* those which do not do this as *non electrolytes* All the acids bases and salts (particularly the stronger acids the stronger bases and the salts formed by their union) are electrolytes while the various sugars urea ethyl alcohol glycerin etc, are familiar non-electrolytes Pure water (practically) does not conduct electricity Neither will it do this when such a substance as dextrose or ethyl alcohol is dissolved in it But the water conducts well as soon as any electrolyte such as sodium chlorid is added to it

The effects of electricity upon the living body whether for good or ill are possible only because living matter contains various electrolyte All therapeutic electrical effects are rendered possible because the body contains electrolytes

The electrolytes behave as they do when dissolved in water because in this solvent they are electrolytically dissociated The atoms and groups of atoms that are the product of such dissociation are electrically charged (herein differing from the ordinary atoms) and are known as *ions* Thus absolutely pure nitric acid (containing no water) does not conduct the electric current nor will it if it is dissolved in some solvent that does not lead to an electrolytic dissociation of the acid This is because under these circumstances only the molecules (HNO_3) of the acid are present But let water be added to the nitric acid, and this at

former of these groups belongs, for example, a solution of gelatin, albumin, globulin, glue, or dextrin, while in the latter might be mentioned the colloidal solutions of ferric hydroxid, aluminium hydroxid, various metallic sulphids and hemoglobin Perrin distinguishes between those colloids which in the solid state are rich in water and those which are poor The former of these Perrin designates as hydrophilic colloids, for the latter the name hydrophobic colloids has been suggested For the purposes of biology these terms are excellent, and in large part adequate For the purposes of physical chemistry in general they have the drawback of not being sufficiently broad Water is not the only solvent that may form the base of a colloidal solution To meet this objection Herbert Freundlich has proposed the name lyophilic colloids for those which show an intimate relationship to their solvent, while those which do not do this are called lyophobic

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the electrolyte may be entirely the sum of the effects of the separate ions that are yielded on dissociation

Water—The water found in living matter and in the media surrounding living matter owes its great physiological importance to its solvent properties The various chemical reactions that are characteristic of and necessary for the maintenance of life are rendered possible by this means, for the solvent properties of water make it possible for the dissolved substances to be brought in contact with each other Water dissolves not only solids such as sugar or salt but liquids, such as alcohol, or gases such as oxygen or carbon monoxid The solutions resulting therefrom still possess many of the ordinary physical properties of water, but new ones also appear which depend upon the quantity and the character of the substance dissolved But the previous state of the dissolved substance is of no importance the resulting solution is the same, for example whether we add to water a certain weight of alcohol in the liquid state or in the gaseous state

We ordinarily think the water in protoplasm to be like the distilled water contained in a test tube in the laboratory This is largely true, but not entirely true The water contained in living matter has the property of dissolving solids liquids and gases as has our ordinary water But the state in which the water is found in the test tube and in living matter is not entirely the same The water found in the body exists almost wholly in the form of *hydration water* that is to say the water forms a compound with protoplasm This is true not only of water found in cells but even of the water found in the blood and in the lymph Uncombined free water analogous to the distilled water in *our laboratory test tube is found only temporarily, and in small quantities*, in the living animal As soon as it appears it is excreted We shall see how important is this distinction between hydration and free water in the body as we proceed The maintenance of all secretion depends primarily upon the obtaining of free water and, as the elimination of all poisonous products from the body whether formed in the normal metabolism of the body or introduced from without (arsenic poisoning), or manufactured in the body in consequence of the introduction of a pathogenic organism into it is secondary to such a secretion of water, we shall see how important these physicochemical facts are from a therapeutic standpoint

STANDARD SOLUTIONS AND COMPARATIVE METHODS IN PHARMACOLOGY

Owing to the fact that many of the chemical materials used in therapeutics represent mixtures of many substances (as, for example, the

once dissociates into its two ions (H^+ and NO_3^-), which carry positive and negative charges of electricity. In an entirely similar way sulphuric acid dissociates into the ions H^+ and SO_4^{--}, sodium hydroxid into Na^+ and OH^-, sodium chlorid into Na^+ and Cl^-. The ions which carry a positive electrical charge wander to the cathode, and are known as *cations*; those having a negative charge move in the opposite direction, toward the anode, and are known as *anions*. Thus hydrogen is the cation of hydrochloric acid (and of all acids), while chlorin is the anion of this same acid (and of all chlorids).

The degree to which a substance in solution is dissociated differs with different substances and varies with the same substance under different external conditions. The greatest degree of dissociation is shown by the so-called *strong* acids, bases, and salts, as, for example, hydrochloric, sulphuric, and nitric acids; sodium, potassium, and calcium hydroxids; sodium chlorid, potassium sulphate, calcium nitrate. But dissociation, even for these, is complete only in extremely dilute solutions. The degree of dissociation increases with every rise in temperature.

For the most part there exist always a certain number of undissociated molecules beside the ions which are the products of the dissociation. For the common salts that we find in our bodies, and under the conditions prevailing in the body, it is ordinarily held that about 85 per cent of the salt present is dissociated into ions, while 15 per cent remains in the molecular state. This means that for every one hundred molecules of sodium chlorid, for example, present in the body, fifteen are present as such, while the remainder have dissociated to yield eighty-five sodium ions and eighty-five chlorin ions.

It is clear after what has been said that, in dealing with the behavior of any substance in solution, this matter of electrolytic dissociation becomes of great importance. If we deal with a substance that is incapable of dissociating electrolytically, or with one familiarly known to us as an electrolyte, but existing at the time under conditions which render dissociation impossible, then it follows that all the effects noted must be due to the properties of the molecules present. A non-electrolyte can exhibit only molecular effects. This holds whether we deal with its properties in the form of a simple solution in the chemical laboratory, or with its biological behavior as brought to our notice by using this same substance as a food or drug (saccharose, glycerin, alcohol).

In the case of an electrolyte, on the other hand, we have to consider not alone the effects of the molecules, but in addition the effects of the ions yielded on dissociation, and not the effects of all the ions together, but of the individual kinds of ions. So, the effects of sodium chlorid become those of molecular sodium chlorid, of the ion sodium, and of the ion chlorin. If the degree of dissociation is very small the ionic effects are correspondingly small, if this is great (complete), then the effects of

bromid, sodium bromid, and lithium bromid, the last named acts more powerfully than the other two. This is on the basis of equal amounts *by weight* of the three substances being given (say in 10 per cent solutions). When we compare the molecular weights of these three substances (which stand to each other as 119.11, 103.01, 86.99) the reason for this apparent inequality in action becomes evident. The chief physiological or therapeutic effect of these three bromids resides in their bromin content and (roughly) a 12 per cent solution of the potassium salt is required to furnish the same amount of bromin as a 10 per cent solution of the (anhydrous) sodium salt, or an 8.7 per cent of the lithium salt. Or to apply this to daily practice, when we substitute a gram dose of lithium bromid for a gram dose of potassium bromid we are giving a third more of the active constituent of our drug.

For certain purposes in pharmacological study it is well to employ *normal solutions*. A normal solution is a gram-molecular solution, provided the dissolved substance is monobasic. In other words the power of the substance to displace hydrogen is taken into consideration. So a normal solution of hydrochloric acid contains a gram molecule (36.46 grams) of the pure acid in the liter of finished solution. But to get a normal solution of the dibasic sulphuric acid only 49.04 grams, that is to say, only one-half the molecular weight (= 98.08) are used; or of the tribasic phosphoric acid only 32.67 grams (= 1/3 its molecular weight 98.02). Similarly a normal solution of sodium chlorid (molecular weight, 58.5) contains 58.5 grams in the liter of solution, while a normal solution of trisodium phosphate ($Na_3PO_4 12H_2O$, molecular weight 380.34) contains only 126.78 grams. Clearly, therefore, the familiar normal solutions of the chemists are the same as the molecular solutions more commonly employed by the physiologists, *provided* monobasic acids or salts are involved. But if polybasic substances are under consideration, then a normal solution of a dibasic compound has only half the concentration of a molecular solution of the same compound, a normal solution of a tribasic compound only one-third the concentration of a molecular solution of this same substance, etc.[1]

A third basis upon which the solution of various substances must at times be standardized is that of their *tonic concentration*. When the electrolytes go into solution in water they become dissociated, as we found above. But the degree of dissociation is not the same for all electrolytes and under all conditions. So, for example, if we take a series of equinormal acids, the number of hydrogen ions in these is by no means the

[1] The "physiological salt solution" or "normal salt solution" of our physiological laboratories, hospitals, etc., has absolutely nothing to do with the normal solutions being discussed here. The terms are misnomers and mean nothing and should disappear from use. We should speak of an 0.85 per cent or 0.9 per cent sodium chlorid solution if that is what we mean by these terms.

various extracts, fluid extracts, and tinctures prepared from plants), accurate quantitative studies on pharmacological behavior have in large part been difficult or impossible. Quantitative methods have increased hand in hand with advances in chemistry that have given us, in place of mixtures, the well-defined chemical bodies that we know as the alkaloids *and the chemically constant active principles of various plants* and organs. Yet, in the comparative study of the behavior of such well-defined chemical compounds, to which we can at once add the various acids, alkalis, and salts that form a goodly portion of our therapeutic armamentarium, we have gotten only little beyond the point in which *percentage solutions* of the various compounds are used. In order to make proper comparisons between the pharmacological action of various chemical compounds, it is necessary for us to compare amounts that are not simply equivalent in weight (as in percentage solutions), but that are equivalent from various physicochemical points of view. A definition of a few standards used in this regard is therefore in order, for we shall have to use these in our further discussion. Comparative studies with solutions of equal percentage are practically worthless, for reasons that will appear shortly.

The *gram molecule* is a convenient unit. This is the molecular weight of the substance under consideration expressed in grams. A gram molecule of hydrochloric acid is 36.46 grams, of sodium chlorid, 58.50 grams, of ethyl alcohol 46.05 grams. If the substance contains water of crystallization the molecular weight of this expressed in grams is added to that of the substance itself. A gram molecule of dried sodium carbonate (Na_2CO_3) is 106.10 grams but of the crystalline compound ($Na_2CO_3 10H_2O$) it is 286.26 grams.

A *gram-molecular solution* (or a *molecular* or *molar* solution) contains a gram molecule of any substance dissolved in enough water to make a liter. If only one-half the gram molecular weight is dissolved in enough water to make a liter we have a one-half molecular solution; if one-eighth the gram molecular solution is present in the liter, a one-eighth molecular solution, etc. Solutions that have the same number of gram molecules of various substances dissolved in the unit volume are *equimolecular*.

It is at once apparent that, if the dissolved substances do not undergo any change on being dissolved, the same number of dissolved molecules are present in all equimolecular solutions. When we employ equimolecular solutions in pharmacological study we are, therefore, able to compare the behavior of a definite number of the molecules of one substance with the behavior of the same number of molecules of another substance.

We can illustrate the advantages of employing such molecular solutions in pharmacological study in place of percentage solutions in the following way. It is ordinarily stated that, of the three salts, potassium

is disturbed, maybe to the point of cessation In the distilled water the ameba loses its salts down to a fatal point from the concentrated salt solution it absorbs more of these than the physicochemical reactions can stand, when the entrance of oxygen into the water is rendered impossible, then none gets into the living ameba and so its normal oxidative processes are interfered with, and it dies

We can, on the other hand kill our ameba by furnishing it the pond water, but by placing it in a position which does not permit it to rid itself of the products of its physicochemical reactions So if we allow the water to get stagnant it will die Under these circumstances the carbonic acid and other products of its activity accumulate in the water about the ameba, and in the ameba itself and as the organism cannot bear more than a certain concentration of these products, it dies

The extremes between which our ameba is able still to maintain itself (minimal salt concentration minimal oxygen concentration maximal carbonic acid concentration) are highly important for its life—they constitute the measure of *the resistance* of the organism to such conditions

What has just been said continues to hold true if without changing another word, we write brain cell or muscle cell or connective tissue cell in place of the term ameba in what we have been discussing For pond water we may substitute the term blood or lymph in place of oxygen above the water we may say the air in the lungs in place of stagnant water we may say sweatshop atmosphere Every cell in the multicellular organism is in the same situation as the ameba and as dependent as this upon the liquid medium that surrounds it If we bear these points in mind, the physical chemistry of a therapeutics that urges water a proper salt ration, the out-of-door life and a ventilated shop system upon us at once becomes clear These are the everyday illustrations of the laws of equilibrium that are ordinarily only murmured within the walls of the laboratory

We shall illustrate this matter of equilibrium a little further Suppose we have any vessel partially filled with water and above this any gas such as oxygen This oxygen will go into solution in the water up to a certain point when no more will be dissolved If now we increase the pressure of oxygen in the space above the water then more of the oxygen goes into solution or if we reduce this pressure some that has *gone into solution will again escape The process is therefore reversible* For any given pressure of the gas there is always a certain amount of this gas dissolved in the water In other words the dissolved gas is always in equilibrium with the gas above it We represent this as follows

Oxygen (Gas)	$\rightleftarrows$	Oxygen (Dissolved in the water)

same Strong acids, such as hydrochloric, nitric, or sulphuric, will in dilute solution be almost entirely dissociated, but the weak acids, such as acetic or carbonic, will be dissociated only very little Suppose, now, that we are trying to determine the relative value of different acids in the digestion of the proteins under the influence of pepsin It is not sufficient under such circumstances to work only with equinormal acid solutions It is also necessary to work with solutions that have the same ionic concentration For the methods employed in the preparation of such solutions the larger textbooks of physical chemistry must be consulted

EQUILIBRIUM

Living matter represents nothing but a series of physicochemical reactions of such a nature that the materials necessary for these reactions are sought by the living matter (that is by certain of the physicochemical reactions themselves) while at the same time the products of these physicochemical reactions, which if allowed to accumulate would bring the whole series to a stop are properly disposed of, the sum total of reactions being accomplished in such a way that the system in which these reactions are taking place (living matter itself) undergoes no marked changes over long periods of time What is meant by a long period of time is simply a matter of definition, in the case of some of the insects it may be but a few hours in some of the higher animals a century The *maintenance of the system constitutes physiology and normal life*, every interference with it pathology and disease The purpose of preventive medicine is the maintenance of the former, the purpose of therapy the relief of the latter, and its restoration, if possible, to the former The whole is governed by the laws of equilibrium

We can best see what all this means in the case of man if we consider the ameba The ameba lives in a state of equilibrium with its surroundings If we take it out of its pond and put it in distilled water it dies If we put it in a strong salt solution it dies, or if we keep it in its own pond water, but cover this so that no air can get to the surface of the water and into solution in the water, it dies The grosser reasons for all this are easily given Pond water contains besides water certain salts and oxygen The water in the organism is in equilibrium with the water in the pond the salts in the organism are in equilibrium with the salts in the pond water, the oxygen dissolved in the protoplasm is in equilibrium with the oxygen dissolved in the pond water To put the ameba under any of the conditions mentioned above is to change one (or indirectly several) of these equilibria, and, if any of them is sufficiently changed, then that normal system of physicochemical reactions that we call life

is disturbed, maybe to the point of cessation. In the distilled water the ameba loses its salts down to a fatal point; from the concentrated salt solution it absorbs more of these than the physicochemical reactions can stand; when the entrance of oxygen into the water is rendered impossible, then none gets into the living ameba, and so its normal oxidative processes are interfered with, and it dies.

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The extremes between which our ameba is able still to maintain itself (minimal salt concentration, minimal oxygen concentration, maximal carbonic acid concentration) are highly important for its life—they constitute the measure of *the resistance* of the organism to such conditions.

What has just been said continues to hold true if, without changing another word, we write brain cell, or muscle cell, or connective tissue cell in place of the term ameba in what we have been discussing. For pond water we may substitute the term blood or lymph; in place of oxygen above the water we may say the air in the lungs; in place of stagnant water we may say sweatshop atmosphere. Every cell in the multicellular organism is in the same situation as the ameba, and as dependent as this upon the liquid medium that surrounds it. If we bear these points in mind, the physical chemistry of a therapeutics that urges water, a proper salt ration, the out-of-door life, and a ventilated shop system upon us at once becomes clear. These are the everyday illustrations of the laws of equilibrium that are ordinarily only murmured within the walls of the laboratory.

We shall illustrate this matter of equilibrium a little further. Suppose we have any vessel partially filled with water, and above this any gas, such as oxygen. This oxygen will go into solution in the water up to a certain point, when no more will be dissolved. If now we increase the pressure of oxygen in the space above the water, then more of the oxygen goes into solution, or, if we reduce this pressure, some that has *gone into solution will again escape. The process is therefore reversible.* For any given pressure of the gas there is always a certain amount of this gas dissolved in the water. In other words, the dissolved gas is always in equilibrium with the gas above it. We represent this as follows:

$$\underset{\text{(Gas)}}{\text{Oxygen}} \rightleftarrows \underset{\text{(Dissolved in the water)}}{\text{Oxygen}}$$

But let us suppose that a substance capable of combining with the oxygen is dissolved in the water. As the dissolved oxygen combines with this substance the concentration of the dissolved oxygen must be reduced and so the pr[illegible] usly established equilibrium is destroyed. In consequence of this more of the oxygen above the water must now be taken up, and this continues until the whole system in which we now have to consider three element [illegible] is more in equilibrium. In other words

Oxygen (A[illegible] the water)	⇄	Oxygen (Dissolved in water)	⇄	Oxygen (Combined)

As a matter of f[illegible] this [illegible] exactly what occurs in the blood when it passes through [illegible] lungs. The oxygen pressure in the alveoli of the lungs [illegible] that [illegible] the oxygen dissolved in venous blood, the oxygen being higher than [illegible] the blood. But hemoglobin is found in the [illegible] passes from the alv[illegible] taking up large quantities of oxygen in [illegible] blood, which is capabl[illegible] librium existing between the oxygen in the a[illegible] sequence of which the equ[illegible] the blood plasma is broken down in the d[illegible] and the oxygen dissolved in [illegible] and so more oxygen is taken up [illegible] tion toward the hemoglobin [illegible] an equilibrium exists in the three phases plasma. And this continues until [illegible] involved, thus

Oxygen (In alveolar air)	⇄	Oxygen (Di[illegible]olved in [illegible]lasma)	⇄	Oxygen (C[illegible] [illegible])

When this arterial blood gets to the tis[illegible] [illegible] the oxygen pressure is lower than that in the blo[illegible] oxygen in the plasma moves over into the body [illegible] this the hemoglobin now gives up its oxygen to the p[illegible] [illegible] continues until equilibrium is again restored.

Entirely analogous conditions prevail in the case [illegible] and the lo[illegible]s of the carbon dioxid from the lungs. The [illegible] produced in the cells and passes over into the blood pla[illegible] by these cells and in which the concentration of carbonic [illegible] than in the body cells. As soon as the carbonic acid gets [illegible] plasma it begins to combine with the carbonates present [illegible] bicarbonates out of them. The carbonates behave in th[illegible] carbonic acid as hemoglobin did before toward oxygen. T[illegible] equilibrium that tend[illegible] to becom[illegible] establi[illegible]hed in the ti[illegible] [illegible]resented as follows

H_2CO_3 (In the cell[illegible])	⇄	H_2CO_3 (Dissolved in the plasma)	⇄	$H_2C[illegible]$ (In c[illegible])

When the veno[illegible] blood get[illegible] to the lungs, wh[illegible] [illegible]he CO_2 of the carbonic acid f[illegible]d

(water remaining behind in the blood) As this happens the bicarbonates break down and give up a part of their carbonic acid to the blood plasma, and this continues until equilibrium is again restored

Attention may here be directed to the rôle of the bicarbonates in maintaining a constant reaction in the organism It is well known that the reaction (hydrogen ion concentration) of the blood and body fluids under normal conditions varies within very narrow limits In terms of the logarithmic symbol suggested by Sorensen and now used quite universally the pH of the blood in normal subjects seldom becomes more alkaline than 7.5 or more acid than 7.3 The pathological variation covers a much wider range pH 7.8 to pH 7.0 When the reaction of blood becomes more acid than 7.0 death results in a short time The mechanism by which a very constant reaction (pH) is maintained is chiefly due to the buffer action of the bicarbonates in association with carbon dioxid Plasma proteins hemoglobin phosphates chlorids free oxygen urea and ammonium salts take part in the buffer mechanism but are of somewhat less importance In the following discussion for the sake of simplicity $NaHCO_3$ will be used to designate the sum of all the bicarbonates In fact sodium is the chief inorganic base in the body

In a solution containing both carbonic acid and sodium bicarbonate the chemical reactions are

$$(1)\ H_2CO_3 \rightleftharpoons H + HCO_3$$

$$(2)\ NaHCO_3 \rightleftharpoons Na + HCO_3$$

$$(3)\ H_2O \rightleftharpoons H + \overline{OH}$$

$$(4)\ H\overline{CO_3} \rightleftharpoons H + \overline{CO_3}$$

$$(5)\ H\overline{CO_3} + H_2O \rightleftharpoons H_2CO_3 + \overline{OH}$$

The equation representing the ionization equilibrium of carbonic acid may be written as follows

$$(6)\ k \times [H_2CO_3] = [H] \times [H\overline{CO_3}]$$

or

$$(7)\ [H] = k \times \frac{[H_2CO_3]}{[HCO_3]}$$

In the presence of bicarbonate there is very little dissociation of the acid so that the concentration of the undissociated molecules may be considered to equal approximately the free acid Furthermore since salts are largely dissociated *the concentration of the bicarbonate ions* (HCO_3) is approximately proportional to the total concentration of bicarbonate Representing this proportionality by a we may write the equation (7) thus

$$(8)\ H = \frac{k}{\alpha} \times \frac{H_2CO_3}{NaHCO_3}$$

It should be clearly appreciated that this expression is an approximation only, and is subject to several modifying factors for a consideration of which the reader is referred to textbooks on Physical Chemistry. This equation has been extremely useful in the study of many physiological and biological problems.

If we now substitute the values for $H = 0.35 \times 10^{-7}$ (reaction of normal blood), $k = 4.4 \times 10^{-7}$ and $\alpha = 0.6$ in equation (8), we have

$$(9)\ 0.35 \times 10^{-7} = \frac{4.4 \times 10^{-7}}{0.6} \times \frac{H_2CO_3}{NaHCO_3}$$

or

$$(10)\ \frac{H_2CO_3}{NaHCO_3} = \frac{1}{21}$$

the proportion of free carbonic acid to bicarbonate in the blood. In order to appreciate the effectiveness of the buffer value of the bicarbonates alone in the blood we may calculate the amount of one-tenth normal acid solution required to change the ratio in a 70 kilo man from 1/21 to 2/21 and determine the effect from equation (8). It may be assumed for purposes of illustration that the concentration of bicarbonates throughout the body fluids is quite uniform, also that 70 per cent of the body weight is water. The concentration of bicarbonate in the normal subject is approximately 0.03 molar.

There are then in our 70 kilo man about 49 liters of 0.03 normal carbonic acid—bicarbonate solution in the ratio of 1 of acid to 21 of alkali. By adding a liter of one-tenth normal acid to the above mixture, the ratio would be changed to approximately 2/21. The effect on the reaction of the blood may be determined by substitution in equation (8).

$$H = \frac{4.4 \times 10^{-7}}{0.6} \times \frac{2}{21} = 0.7 \times 10^{-7}$$

That is, in spite of the large amount of acid added to the solution, the reaction (hydrogen ion concentration) of the blood has been changed from

$$0.35 \times 10^{-7} \quad \text{to} \quad 0.70 \times 10^{-7}$$

which is still within the limits compatible with life.

The importance of the above-described equilibrium can scarcely be overestimated. The ease and regularity with which the respiratory mechanism eliminates CO_2 provides a very wide margin of safety in … action of body fluids within safe limits. Even under the … al metabolism, such as is encountered in diabetic acidosis,

the reaction of the blood is maintained within normal limits, although the total bicarbonates may be depleted to within one-fifth its normal concentration The importance of a clear understanding of regulation of the acid base equilibrium within the organism becomes apparent in the treatment of acidosis (see chapter on Acidosis)

A classical example of purely *chemical equilibrium* is furnished by the combination of ethyl alcohol with acetic acid If at a definite temperature chemically equivalent amounts of acetic acid and ethyl alcohol are mixed together a reaction ensues according to the following equation,

$$\underset{\text{(acetic acid)}}{CH_3COOH} + \underset{\text{(ethyl alcohol)}}{C_2H_5OH} = \underset{\text{(ethyl acetate)}}{CH_3COOC_2H_5} + \underset{\text{(water)}}{H_2O}$$

The reaction takes place in the direction from left to right If, now, we mix together chemically equivalent amounts of ethyl acetate and water, ethyl alcohol and acetic acid are formed In other words the above reaction takes place from right to left Neither in the first nor in the second instance does the reaction become complete Before the given amounts of acetic acid and ethyl alcohol or ethyl acetate and water have undergone complete decomposition the reaction comes to a standstill Such a reaction which can take place from right to left as well as from left to right is called a *reversible reaction* We indicate this as we have done above in the case of oxygen and carbonic acid as follows

$$CH_3COOH + C_2H_5OH \rightleftarrows CH_3COOC_2H_5 + H_2O$$

It can be readily seen that when equilibrium is established in a reversible reaction, the four substances reacting with each other are present in the reaction mixture The characteristic feature of such a condition of equilibrium is found in the fact that under the same external conditions it is always the same, no matter from which side it is reached In other words it is immaterial whether chemically equivalent amounts of acetic acid and ethyl alcohol or chemically equivalent amounts of ethyl acetate and water are mixed together The condition of equilibrium is in the end the same in either case

Although we say ordinarily that when equilibrium has been established the reaction has come to a stand still this is really incorrect When equilibrium has been established between the two sides of an equation it really means that the chemical changes are still going on only the amount of change in the one direction is exactly counterbalanced by the reverse change in the opposite direction The reaction is, therefore *stationary*

What happens if after equilibrium has been established we introduce into the reaction mixture either ethyl acetate or acetic acid and alcohol or remove either of these from the amounts that are present? Clearly

$$(8)\quad H = \frac{k}{\alpha} \times \frac{H_2CO_3}{NaHCO_3}$$

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and adequate therapy, or an intoxication Upon the maintenance of a sufficiently low concentration of the involved substances in the second case (circulation of fresh water about the ameba administration of water to a poisoned man) depends the removal of the poisonous substances from the intoxicated cell while there resides in this good therapeutic procedure the danger at the same time of injuring the involved cells by allowing the diffusion out of them of some of their normal constituents

We have now to consider some of the factors that modify the problem of diffusion as this operates in the living animal Thus far we have entirely ignored the *time factor* and secondly the fact that living cells are more than mere isolated drops of water In other words the nature of the diffusing substances and the constitution of protoplasm affect this process of diffusion as originally described in our cylinder of water at the bottom of which we had placed a concentrated copper sulphate solution

We have already touched upon one great classification of the various substances that are concerned in the physiological and therapeutic aspects of this problem of diffusion The state in which a chemical compound exists affects its diffusion behavior The colloids we noted above scarcely diffuse at all when compared with the way in which crystalloids diffuse Herein for example, resides one of the great purposes of digestion Through digestion the colloid proteins, carbohydrates and fats are changed into compounds that are crystalloidal in character and so from a state in which they practically cannot diffuse into living cells to one in which they do this promptly

But even among the crystalloids the rate at which diffusion occurs is by no means the same The diffusion velocity of sodium chlorid dextrose and magnesium sulphate decreases in the order named Similarly the rate of diffusion of these substances into cells (their absorption) decreases in the order named

Along with these specific differences in the rate of diffusion of different dissolved substances we have to remember that, if we are dealing with a mixture of diffusing substances the one may modify the rate of diffusion of the other as this would have appeared had it alone been in solution (Arrhenius)

Another factor that influences this problem of diffusion as observed in living matter resides in the fact that protoplasm is not a pure solvent (water), but a colloidal mass It used to be held that diffusion occurs just as readily into and through such a colloidal mass as gelatin or agar agar as into and through pure water but this is not strictly true The presence of colloidal material retards the rate of diffusion of dissolved substances and this the more the higher the concentration of the colloid in the medium into which diffusion is occurring Or to apply this to the problem of pharmacology a dissolved substance will enter the protein portions of a cell less rapidly than pure water or, if different cells

this must disturb the existing equilibrium, and, depending upon the side upon which this disturbance has taken place, more ethyl acetate and water must be formed, or more ethyl alcohol and acetic acid

Upon the operation of these laws of equilibrium depend not only all the processes of normal absorption and secretion by the living animal, but all those of abnormal absorption and secretion that are better known to us under the headings of *intoxication* and its reverse, *detoxication* How to prevent the former, and how to aid the latter, constitute two cardinal problems in therapy

DIFFUSION

If we very carefully pour some distilled water upon a concentrated solution of copper sulphate the colored layer does not immediately mix with the clear water above it If we set the apparatus aside in a quiet place and watch it we notice that the blue color gradually spreads upward through the clear water until in the end the whole vessel contains a uniformly blue solution The dissolved particles of copper sulphate spread upward into the clear water by a process of *diffusion*

To return once more to our ameba in its pond water (which we have made analogous to the individual cells composing man surrounded by their blood and lymph), we can say that all the substances necessary for the life of this ameba, or the various poisons that may be added to the pond water to injure or kill the ameba, get from the pond water into the organism by a similar process of diffusion Conversely, the poisonous products formed by the ameba in its daily life, or the substances which have accidentally found their way into the organism and are capable of acting as poisons, can get out of the ameba into the surrounding medium (and so be swept away) only through this same property of diffusion

We have already discussed how important a part the laws of equilibrium play in this process of diffusion Diffusion is possible only because the distribution of the dissolved substances in the system under discussion is not of such a character as to have the whole in equilibrium Food substances oxygen and poisons diffuse into the living ameba because the concentration of these within the ameba is less than that necessary to establish an equilibrium between the substances as found here and the same substances found in the pond water Similarly, the various poisonous products and many of the normal constituents of protoplasm, notably the salts, diffuse out because the concentration of these in the pond water is less than sufficient to be in equilibrium with these same substances as found in the protoplasm of the ameba Upon the maintenance of a proper concentration of food supply medicinal agent, or poison in the pond water (or blood and lymph) depend in the first instance proper nutrition

and adequate therapy, or an intoxication Upon the maintenance of a sufficiently low concentration of the involved substances in the second case (circulation of fresh water about the ameba, administration of water to a poisoned man) depends the removal of the poisonous substances from the intoxicated cell while there resides in this good therapeutic procedure the danger at the same time of injuring the involved cells by allowing the diffusion out of them of some of their normal constituents

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are involved, it will enter most rapidly into those which are richest in water. Now, since the water capacity of any tissue cell varies under physiological and pathological conditions (normal water content and edematous state), it is evident that correspondingly herewith substances may diffuse into cells more rapidly at one time (say in certain diseases) than at another.

DISTRIBUTION

Thus far our argument has shown us that diffusion occurs from a region of higher concentration to one of a lower concentration, and has seemed to indicate that this will go on until the concentration of each of the diffusing substances is the same everywhere. In other words, it has seemed as though the attainment of a state of equilibrium is synonymous with equality of distribution.

So, for example, in our ameba we have made it appear that equilibrium would be established between the ameba and the pond water surrounding it as soon as the concentration of every dissolved substance in the two phases is the same. The same would hold true of the individual cells of the multicellular organism. So we might suppose that after a dose of potassium iodid or strychnin or alcohol to a patient equilibrium would be attained as soon as the distribution of these various drugs was the same in all the tissues and fluids of the body.

Actually we know that nothing of the sort occurs. In fact we know that a uniform distribution of any dissolved substance throughout the cells and fluids of a living organism probably never occurs. So the concentration of the various salts in the ameba is not that of these same salts in the pond water, and the potassium iodid, the strychnin, and the alcohol distribute themselves very unequally through the multicellular organism. The iodids are likely to accumulate in the thyroid, the strychnin in the spinal cord, the alcohol in the brain. These inequalities in distribution are pointed to by men who believe that we shall never be able to interpret all life phenomena on a purely physicochemical basis as evidences indicating that living matter has "peculiar" properties not known to the physical chemist in his study of "dead" material. Such pessimism is at least premature. As the following shows, we are already in a position that permits us to account very easily for a large bulk of these phenomena.

Causes of Inequalities in Distribution

Inequalities in Solubility.—When we take a solution of iodin in water and cover this with a little ether and shake the whole, we can see even from naked eye appearances that the iodin is ultimately present in

very unequal concentrations in the two liquids While scarcely any color remains in the water, the ether shows a deep coloration with iodin The process is a homely illustration of the everyday chemical procedure that we call shaking out with an immiscible liquid' The extraction of the iodin from the water by the ether depends upon the fact that iodin is soluble in the ether and, in the example cited, the solubility of the iodin is so decidedly greater in the ether than in the water that practically all the iodin moves over into the ether phase The ultimate state of equilibrium attained, which is characterized by this very unequal partition (distribution) of the dissolved substance between the water phase and the ether phase, is in this case due to the difference in the relative solubilities of the iodin in the water and in the ether As the iodin is more soluble in ether than in water, most is ultimately found in the ether phase If we take equal volumes of water and ether and drop into the mixture a measured amount of iodin, say a gram, we find when equilibrium has been attained that (roughly) one-tenth of this has dissolved in the water and nine-tenths in the ether If we use instead 2 grams of iodin, we have again the same proportionate distribution of the iodin, one-tenth of the amount added goes into the water and nine tenths goes into the ether And this result is constant no matter whether we first mix the water and the ether and then add the iodin and whether we dissolve the iodin in the ether and then add the water or vice versa In the end the state of equilibrium attained is always the same The proportion of iodin dissolved in each of the two phases—in this case a concentration of iodin nine times as high in the one as in the other—is always constant We call this the *distribution coefficient* or *coefficient of partition*

In our discussion of the living cell so far we have spoken of its solvent powers for various substances chiefly from the standpoint of its water content If the cell had solvent powers only so far as its water content is concerned it is obvious that dissolved substances could never appear in it in higher concentrations than those of these substances in the media surrounding the cell But this conception of the cell is too limited In addition to water the various cells of all living organisms contain fat and fatlike bodies The latter are called lipoids and include such substances as cholesterin lecithin protagon, and cerebrin We can see in advance therefore, that the living cell must be able to take up (that is, dissolve or absorb) many substances that are better soluble in such fats and lipoids than in water in greater amounts than the media surrounding these cells which are less rich in, or devoid of these substances

We are indebted to Hans Meyer and to F Overton for recognizing the great physiological and pharmacological importance of the facts here outlined (The distribution law of Berthelot and Jungfleisch) By methods which we need not discuss here, these authors found it pos

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words, it depends upon the distribution coefficient of the dissolved substance between the two phases (water and etherlike bodies) whether any dissolved substance will enter a cell slowly or rapidly, and whether it will ultimately be found in the cell in a greater, in the same, or in a lower concentration than in the medium surrounding it

With these ideas in mind it is only necessary to reexamine the list of substances which experiment has shown enter cells with more than usual velocity and see if they are not all of them of a character which renders them more soluble in ethereal or oily substances than in water and if those which stand first in the list and consequently enter cells most rapidly are not such as have the highest distribution coefficients in favor of the ethereal or oily substances An illustration or two may make this clearer The repeated substitution of an atom or a group of atoms for some other atom or group of atoms in a chemical compound is often accompanied by marked changes in the solubility of the compound and its derivatives Glycerin enters a cell only very slowly When an atom of chlorin is introduced into this compound, the new compound obtained enters protoplasm more rapidly and when two are introduced, still more rapidly for these derivatives are more readily soluble in fats than the original glycerin. The same holds true of urea and its methylated derivatives While urea diffuses but slowly into cells, the introduction of one, two or three methyl radicals into this compound increases progressively its solubility in fats, and also the rate of diffusion into living cells

The tremendous pharmacological importance of these simple facts is self-evident In order that a substance may produce any physiological effect it must first get into the cell Other things being equal we may therefore expect a quicker and a more powerful effect from a lipoid soluble pharmacological preparation than from one that is not thus soluble Upon this depends a whole chapter in the chemistry of pharmacological preparations in which some pharmacologically active compound which in itself gets into cells only slowly and so is not very active, is made active by being introduced into some compound which is more readily soluble in the lipoids

The marked effect of all the anesthetics (chloroform ether alcohol ethyl chlorid), and the various alkaloids (morphin, cocain atropin), is associated with the fact that they are lipoid soluble Their great effects upon the central nervous system are in large measure associated with the fact that nervous tissues are rich in fat and fatlike bodies, and so these tissues take up these substances with special avidity We can appreciate also why a fat individual demands more anesthetic before going to sleep than does a lean one Anesthesia, like all intoxication, is a matter not of absolute amount present, but of concentration The various grades of anesthesia go hand in hand with definite concentrations of anesthetic in certain cells of the central nervous system It must

sible to differentiate between substances which pass into or through cells very slowly, and those which pass rapidly

To the compounds which diffuse rapidly into protoplasm belong the monatomic alcohols, aldehyds, and ketones, the hydrocarbons with one, two, and three chlorin atoms, the nitro-alkyls, the alkylcyanids, the neutral esters of inorganic and many organic acids, anilin, etc. The diatomic alcohols and the amids of monatomic acids pass into cells more slowly, and still more slowly glycerin, urea, and erythrite The hexatomic alcohols, the sugars with six carbon atoms (hexoses), the amino-acids, and the neutral salts of the organic acids diffuse into cells only very slowly (Overton)

A simple glance at the list just given shows that we have to deal here with all manner of chemical substances Some of these are relatively simple in composition some very complex, some are of physiological importance, and are found as normal constituents of the living cell, others are entirely foreign to the living organism What physicochemical character have all these substances in common, which allows them to penetrate living cells with more than usual ease, and so to stand out from the great group of the ordinary neutral salts, for example, which can penetrate the cells only much more slowly?

An explanation frequently given and long believed to be the correct one is that the size of the molecules is the condition which determines the entrance of the dissolved particles According to this conception, the cell protoplasm as a whole, or the "membranes" (to be discussed later) believed by many (including Overton) to exist about cells, are regarded as sieves which allow all molecules that do not exceed a certain size to pass into the cell, while those larger than this are held back The deficiencies of any explanation which calls for the existence of membranes about cells we will point out later, but even now it must be apparent that the sievelike behavior attributed by some authors to such membranes or to protoplasm as a whole lacks all support, for cells which readily give passage to such large atomic aggregates as the alkaloids and sodium salicylate hold back the much simpler amino acids and potassium sulphate

The substances enumerated above enter cells because the cells contain substances which in their properties as solvents behave not unlike ether All those compounds which are more soluble in ether (and other oil-like bodies) than in water must, therefore, pass into and through cells containing etherlike solvents (fat, cholesterin, lecithin, cerebrin, protagon), more rapidly than into and through such as do not contain such solvents, and with a given cell the rapidity and the absolute amount of any compound ultimately taken up must depend upon the relative degrees of solubility of the substance concerned in water and in the etherlike bodies contained in the cells (distribution coefficient) In other

have had the charcoal take as much of the dye out of the solution as is possible we pour off the supernatant liquid and substitute pure water for it, then some of the dye will leave the charcoal and go back into solution in the water In this way we can again wash all the dye out of the charcoal Conversely, if, after we have had the charcoal take up as much dye as possible we add more dye to the supernatant liquid then the charcoal will proceed to take up an additional amount from that which we have added

The relationship between the concentration of the substance to be adsorbed and the amount taken up by the charcoal is an interesting one, and may be thus stated From relatively dilute solutions the adsorbent will take up much, from more concentrated solutions relatively less, of the substance to be adsorbed In other words if at a certain concentration we can take four fifths of the dye present in a solution out of this with a given amount of charcoal then, if the dye has a higher concentration we can take out only less than four fifths or, if it has a lower concentration more than four fifths

Protoplasm behaves toward substances dissolved in a medium that surrounds it in an entirely similar way This constitutes another reason why protoplasm may contain the same, a higher, or a lower concentration of any dissolved substance than the medium surrounding it The protoplasm (adsorbent) of different cells behaves differently toward the same external conditions and so it comes to pass that, while all cells are bathed with essentially the same blood and the same lymph they do not all adsorb the same amount of the proffered materials In other words, equilibrium is not attained between the protoplasm of different cells and the medium surrounding these at exactly the same point Hence it happens that the salt content of different cells is not only not the same under physiological conditions, but, if we offer the cells of the body any pharmacological preparations (say an iodid) all the cells of the body will not take this up equally So the thyroid for example because of its peculiarly high adsorbent powers for the iodids, will be found particularly rich in iodin after medication with this drug, iron will tend to collect in the liver and the mammary glands, etc.

The adsorption properties of protoplasm are markedly influenced by various external conditions If we alter the reaction of the medium in which protoplasm finds itself (say from the normally neutral to an acid one), then the adsorption powers change most markedly Thus a given tissue which under normal circumstances proved an excellent adsorbent for certain dissolved substances may practically lose this or conversely a tissue which before adsorbed a given substance only poorly may now take this up with avidity The pharmacological import of this is easily seen The former is equivalent to a defective adsorption, the second to an abnormally good adsorption The maintenance of a normal

evidently take longer to attain this concentration in a fat man than in a lean one, for the ready solubility of the anesthetics in fat means that the ordinary fat-containing cells of the body must be saturated with anesthetic at the same time that we are trying to do this to certain cells in the central nervous system And so a greater initial absolute amount of anesthetic must be taken up by a fat individual than by a leaner one

Inequalities in Distribution Due to Inequalities in Adsorption—Not only may a living cell come to contain in the unit volume a greater amount of a dissolved substance than does the surrounding medium because the cell contains better solvents for the dissolved substance than does the surrounding medium, but it may take up an unexpectedly large amount because of its *adsorptive* powers These adsorptive powers are associated with the fact that the cell is largely colloidal in its make-up The general problem of adsorption may be illustrated as follows

If we dissolve a dye in distilled water, we get a uniformly colored solution If, now, we divide the solution into two parts, and add to the one a little finely powdered charcoal and then shake both, we find after a little time that while our control solution remains entirely unaltered, the color has very largely disappeared from the other We are not dealing here with a chemical reaction, the pure carbon that we added to the colored solution does not react chemically with any of the constituents in the tube The powdered charcoal has a great surface, and the action of this great surface upon the dissolved particles of the dye has made this accumulate (condense) upon the surface of the charcoal The theory of how this surface action is accomplished need not interest us here

What has been described is an example of *adsorption* The charcoal used in the experiment is the adsorbent, the dye the adsorbed substance

An enormous number of substances could be cited as acting under various conditions as such adsorbents, and almost any substance could be given as an example of a material capable of being adsorbed Kaolin, finely divided precipitates of all kinds or any of the inorganic or organic colloids may take the place of carbon in the above experiment, and acids, alkalis and salts can be adsorbed in the same way as our readily visible dye Examples of adsorption are familiar to every one The chemical decolorization of beers, sugars, etc, under the influence of animal charcoal, the removal of color from a bath by dipping wool, cotton, etc., into it (dyeing), the staining of histological specimens, are all examples of adsorption

The adsorption of any substance by an adsorbing agent is never complete In the case of a dye and charcoal, it is never possible to take all of the dye out of the bath with the charcoal, a little always remains behind In other words, the distribution of the dye between the solvent and the adsorbent is governed by the laws of equilibrium If, after we

bility characteristics, the phenomena of adsorption and chemical combination, influence the point at which equilibrium is reached This simple picture of the cell furnishes to our minds an adequate conception of its main structure

But this is not the conception of the cell which all, or even the majority, of biological workers accept as correct Since the studies of W *Pfeffer and Hugo de Vries it has been generally held that both plant* and animal cells have membranes' (osmotic membranes or semipermeable membranes) about them This is a teaching which we believe incorrect The question is discussed in greater detail later but it is brought up here because, if such membranes existed about cells, they would be an additional factor in determining the distribution of dissolved substances between cells and their liquid surroundings

The original teachings of Pfeffer and De Vries held the membranes about cells to be entirely analogous to the osmotic membranes (the so-called semipermeable precipitation membranes) of the physical chemists Such membranes are freely permeable to the solvent (water), but impermeable to substances dissolved in the solvent Did such membranes exist about cells it is therefore clear that water could freely pass into and out of cells but the substances dissolved in the water surrounding the cells could not get in, and those in solution within the cell could not get out

On the face of things it is evident that such a conception cannot be wholly correct for if cells had true semipermeable membranes about them no food materials could ever get into them, no products of metabolism get out, and this would mean death So for these true semipermeable membranes the more modern school has substituted such as are partially permeable and very complicated these are As we do not think that any such complicated structures exist, we shall not discuss them further We only wish to emphasize the fact that should such membranes ultimately be shown to exist about cells they will be capable of maintaining concentration differences (at least for shorter periods of time) between the dissolved substances within the cell and those without for, if a membrane is permeable only to some dissolved substances then those which cannot pass through may accumulate in unusual quantities either within or without the cell

PHARMACOLOGICAL IMPORTANCE OF THEORY OF ELECTROLYTIC DISSOCIATION

In the earlier portions of this chapter it was found that the crystalloids can be divided into two great groups the electrolytes and the non electrolytes When the electrolytes go into solution in water we find

physiology (absorption of food) depends upon the former, or the proper absorption of a pharmacological preparation Loss of adsorption power may, therefore be followed by serious consequences On the other hand, an increased adsorption power may be equally dangerous, for a pharmacological preparation which is absorbed but little by a given healthy tissue *may in disease be absorbed so well that it produces unexpectedly powerful* effects

Specific Chemical Differences — A third reason why a cell may contain substances in a higher (or lower) concentration than the medium surrounding the cell resides in the fact that the cell may contain substances capable of combining chemically with the proffered dissolved substance So, for example if a cell contains iron, it is reasonable to expect in advance that this cell will take up more of a proffered poison capable of combining with the iron (say a ferrocyanid) than a cell not containing iron, or iron in less amount. We need not multiply such illustrations, for the list is as long as the list of chemical reactions capable of ensuing between the various substances found in any living cell and the substances that come normally or abnormally in contact with this cell

All the "specific effects of various pharmacological preparations of "toxins," or ferments,' etc, and the 'specific reactions' of protoplasm due to these, are generally regarded and might be used in illustration of such inequalities in distribution as we are here discussing This point of view is in the main correct But it is likely to be carried too far We are still too strongly under the influence of the "purely chemical' point of view in this matter We have already learned that many of the "specific immune reactions' are not so intensely 'specific," and the whole realm of colloid chemistry is dotted with examples of reactions that have been looked upon as "chemical' in character when further analysis has shown that what was considered "specific" in these reactions did not depend upon the presence of certain chemical compounds, but rather upon the physical states in which the components of the reactions entered into these

Interference from "Membranes —Were we to sum up in a few words our conception of the structure of protoplasm as thus far developed, we could liken it fairly accurately to a mass of gelatin (protein) intimately mixed with more or less fatlike material (the fats and lipoids), the whole being under physiological conditions immersed in a liquid (pond water in the case of our ameba, or lymph and blood in the case of our body cells), from which the protein fat mixture soaks up a certain amount of water as well as the various dissolved substances found in this water What governs the matter of water absorption we shall have occasion to discuss shortly The absorption of the dissolved substances we have made a matter of equilibrium between the medium outside the cell and the medium which constitutes the cell, and we have indicated how the solu

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water When the toxic effect of solutions of different mercury compounds containing the same amount of mercury in the unit volume are compared, it is found that, in spite of this fact, they have a very different degree of toxicity Thus mercury sulphocyanate is more toxic than mercury cyanid, and this more toxic than mercury thiosulphate While all these compounds yield mercury ions when dissolved in water they yield an unequally great number Corresponding to the fact that the first yields the largest number, it is found to be most toxic

The next evidence in this direction was brought by Grutzner who showed that the toxic effect of various acids on nerves was chiefly a function of the hydrogen ions the acids yield and that the degree of toxicity of different acids parallels (roughly) the degree of dissociation of the acids in other words the concentration of the hydrogen ions Kahlenberg and True brought out the same fact in studying the effect of various acids bases and salts on the growth of sprouting beans These authors found that such sprouting beans will just live in solutions of the strong acids (HBr, HCl HNO_3 H_2SO_4) when a gram molecule of these substances is dissolved in 6 400 liters of water In solutions as dilute as this, dissociation into ions is complete and there are no longer present any molecules of the acid Hence, the toxic action cannot be due to the molecules of acid The toxic action can therefore be due only to the hydrogen ions or to the different acid ions or to these together No toxic effect is shown by a sodium chlorid solution which is equimolecular with a toxic hydrochloric acid solution and since such a sodium chlorid solution yields just as many chlorin ions as the acid solution, the toxic effect of the acid solution cannot be due to the chlorin ions It must therefore, be due to the hydrogen ions

By similar methods it can be shown that the toxic effect of hydroxids is chiefly a function of their hydroxyl ions Sodium chlorid solutions having a concentration equivalent to toxic sodium hydroxid solutions are non poisonous Since both contain sodium ions and in the same concentration and since the hydroxid solution is toxic at a concentration when dissociation is complete the toxic effect of the sodium hydroxid must be due to the hydroxyl ions

In the same way J Loeb has shown that the loss of irritability of a muscle and the amount of water this absorbs in an acid solution is a function of the ions of the acid concerned Richards has shown that the taste of acids, alkalis and salts is dependent upon the ions they yield Kahlenberg and True Paul and Kronig and Scheurlen and Spiro that the antiseptic action of various metallic salts (mercury silver gold) is determined in the main by the ions they yield and is the greater the higher the number of poisonous ions yielded

Since these earlier papers an enormous literature has sprung up around this general subject of the physiological effects of ions

them to undergo dissociation, so that ions result When we deal with the effect upon protoplasm of various electrolytes dissolved in water, do we deal with effects of the molecules of these electrolytes, or with the effects of the various ions which they yield on solution? So far as the pure chemistry of the electrolytes is concerned, we know that their behavior is determined in the main, by the ions they yield on solution So for example, the various group reactions that we are familiar with in chemistry are now known to be essentially reactions between ions of the same kind The reason that all acids taste sour, redden litmus, and attack metals is that on solution in water all acids yield hydrogen ions—the property that all acids have in common Alkalis, on the other hand have an alkaline taste turn litmus blue, etc, because all have hydroxyl ions in common

The specific differences between different acids arise from the fact that the radicals united with the hydrogen in the molecular acids are different, and when dissolved in water these form different kinds of ions So hydrochloric acid and nitric acid, when dissolved in water, are the same in that both yield hydrogen ions, but different in that the one yields chlorin ions in addition, while the other yields NO_3 ions Similarly, the specific differences between the bases are to be sought in the specific differences between the metals with which the hydroxyl in the base is combined On solution in water the bases are all the same in that they yield hydroxyl ions, but different in that sodium hydroxid yields in addition sodium ions potassium hydroxid potassium ions, and calcium hydroxid calcium ions

When silver nitrate is added to a mixture of different salts all the chlorids are precipitated This is because all the chlorids on solution in water yield chlorin ions and the silver ions of the silver nitrate react with these and produce a precipitate When silver nitrate is added to a substance in solution which contains chlorin but not in a form which makes this appear as chlorin ions, no such precipitate is formed Thus silver nitrate does not precipitate the chlorin from a chlorate, for this does not yield Cl ions as does the chlorid, but ClO_3 ions nor the chlorin out of chloroform which is a non-electrolyte and therefore yields no ions at all

When we deal *with the effects of the various acids, bases, and salts* upon protoplasm, in other words, with the effects of these various electrolytes do we deal with the effects of the various molecules of these compounds or with the effects of the various ions that these yield in solution? In greater part we deal with the effects of the various ions that these yield

The first proof of the truth of this statement was brought by H Dreser, and in the field of pharmacology Dreser was working with the effects of different mercury salts, and showed that their toxic action was primarily a function of the mercury ions they yield on solution in

The proteins and the effect of various external conditions upon them have been studied from many points of view. Those which are most important from a medical standpoint are the relationship of water absorption to the state of the colloid, the viscosity of the colloid, and the precipitation or coagulation of the colloid. As we shall see shortly, a very simple relationship exists between these apparently detached properties of the colloid. To indicate the importance of a knowledge of the changes that occur in these simple properties of the colloids under various external conditions we need but mention the fact that the first of these properties of protein colloids controls, in the main, the whole question of how much water the cells or fluids of the body will hold under physiological and pathological conditions (normal cell turgor, edema); the viscosity of protein solutions is associated with the work the heart must do in pumping the blood, the general problem of protoplasmic motion (migration of leukocytes, contraction of muscle), and the phenomena of cell division, their precipitation and coagulation, with such changes as the steaminess of the cornea in glaucoma, the graying of the parenchymatous organs in "cloudy swelling," the changes produced by acids, caustics and the metallic salts in pharmacology, etc.

It is convenient to begin our discussion with the matter of water absorption by such protein colloids as gelatin or fibrin.

When gelatin or some powdered fibrin is thrown into water it swells up somewhat. If the experiment is done quantitatively and the gelatin or fibrin is thrown instead into a dilute acid, it is found that the colloid swells up very much more. Depending upon the concentration of the acid, these colloids swell more and more with every increase in the concentration. But this is true only within certain limits. After a time a point is reached where the gelatin or fibrin does not swell more with a further increase in the concentration of the acid, but less. While all acids make gelatin or fibrin swell they are not equally powerful in this regard. When equinormal acids are compared hydrochloric acid is found to act more powerfully than nitric, and this more powerfully than lactic or acetic, in the order named. Sulphuric acid stands below these organic acids.

These simple facts are of the greatest biological importance. What we have said regarding the action of acids on protein colloids can be said without modification for the effect of acids in the most varied physiological and pharmacological reactions. The same laws govern the way in which these acids reduce the irritability of nerves and muscle, kill

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It is necessary to distinguish between these two terms for they represent radically different changes in the state of a colloid. We use the term precipitation if the change is reversible. We speak of the precipitation of a protein with a salt of some kind if on removing the salt the protein goes back into solution. If it fails to go back into solution we say it is coagulated—in other words the change is irreversible.

EFFECT OF VARIOUS EXTERNAL CONDITIONS ON COLLOIDAL STATE

Our discussion thus far has brought us to a realization of the fact that the reactions which characterize the living cell occur in a colloidal medium, it has further indicated the means by which various dissolved substances get into and out of this colloidal substance We have now to discuss the relation of these two to each other, in other words, the action of the various substances which manage to get into or are produced in and fail to get out of a cell upon this colloidal matrix and, conversely, the effect of the matrix upon the substances dissolved in it

We can sum up the problem involved from our special viewpoint by discussing *the effect of various external conditions upon the physical state of colloidal material* What is said under this heading may then with slight or no modification be directly applied to living protoplasm We shall choose for special discussion the effects of a limited number of external conditions that are of interest because of their bearing upon pharmacology and therapeutics

All colloids, including those found in the living animal, are conveniently classed, as we found above, into suspension colloids and emulsion colloids This classification is made, as was pointed out, on the basis of the relationship that exists between these colloids and the solvent in which they find themselves The suspension colloids are not so intimately associated with their solvent as are the emulsion colloids While we can readily separate the solvent from the colloid in the first case, this is done only with great difficulty in the second It is possible, for example, to separate in some suspension colloids (the colloidal metals) the solvent from the colloid by suitable methods of filtration, in the emulsion colloids no such simple procedures suffice If we take a swollen piece of gelatin, for example, it is well nigh impossible to squeeze the water out of it by any gross mechanical means

Of the colloids that compose the mass of the animal body, the emulsion colloids constitute the chief bulk In muscle for example, we have about 75 per cent water Of the 25 per cent of solids only 1 per cent is ash, the rest is, in the main, emulsion colloid material

Of the emulsion colloid material found in any cell or group of cells in the animal organism, the main bulk is protein and as this has been studied with special care by Hofmeister, Spiro Pauli, Hardy, Wolfgang Ostwald, von Schroeder, Handovsky, Schorr, Gertrude Moore and myself, we will devote our chief discussion to it In this way we shall get at once not only a simple explanation of many phenomena that are familiar to every worker in medicine, but valuable principles upon which to base a rational therapy

the acid side Carbonic acid is the common product of normal carbohydrate and fat metabolism, and, when the normal metabolism gives way to an abnormal one the tendency of the tissues to become acid is enormously heightened, for in place of carbonic acid much stronger acids are produced

These facts may be at once transferred to our knowledge of the pharmacological behavior of many items in our pharmacopeia We can see, first of all, why the electrolytes are in general far more active physiologically than the non electrolytes But we can go further than this That long series of physiological reactions which we have found to be identical point for point with the reactions of these simple colloids toward various external conditions may now safely be regarded as reactions on the part of the colloids of the cell toward these same external conditions

A substance like fibrin under ordinary circumstances merely swells up in water, it constitutes a semi solid mass The same is true of gelatin at lower temperatures We can without overstating the case, make the behavior of tiny fragments of fibrin identical with the behavior in certain directions of individual cells Tiny fragments of fibrin have the consistency, the pliability, and the powers of water absorption and secretion that are possessed by the individual body cells say, for example the red blood-corpuscles Fibrin behaves therefore, like the solid constituents of our bodies A mass of fibrin or a gelatin cake behaves not unlike a mass of animal cells In certain directions a mass of gelatin behaves like a muscle, an eye a kidney, or a brain But such semi solid structures do not compose all of our bodies Permeating these, we have streams of liquid colloid material called the blood and lymph, that are kept in constant motion by the heart the pressure of muscles upon the vessels the aspiration of the thorax etc We have been content to speak of these circulating streams, thus far in their relationship to the body cells, as identical with the pond water that washes about our primitive ameba And this remains true but there is one important difference between the pond water and our blood and lymph This depends upon the fact that pond water is practically free from colloids, it is to all intents and purposes plain water in which some crystalloidal electrolytes and non-electrolytes are dissolved Blood and lymph on the other hand are high in colloids The water in pond water is essentially free In the blood and lymph there is no free water all the water is held in combination with the colloids found in them and the electrolytes and non electrolytes of the blood and lymph are carried in this colloid water matrix

The blood is essentially liquid in character It corresponds in its behavior not with a solid cake of gelatin but rather with a solution of gelatin not with a mass of solid albumin like fibrin but with a dissolved albumin like egg white a globulin or serum albumin Let us ask, there-

bacteria and the cells of higher plants, affect the sense of taste, influence chemotaxis (Garrey), favor the absorption of water by animal and plant tissues, favor proteolysis under the influence of pepsin, etc We are safe in believing, therefore, that the point of attack of the acids is the proteins in the tissues, and that they influence the various biological phenomena considered by changing the state of these colloids in the same way that they change the state of our gelatin or fibrin

The swelling of gelatin or fibrin in any acid solution is reduced through the presence of any salt, even a neutral salt So, if we add sodium chlorid to a lactic acid solution, the gelatin or fibrin contained in this medium will not absorb as much water as when the salt is not present The more salt we add, the more is the swelling of the colloid reduced, and if we add enough the swelling may be stopped entirely

While in general the observations mentioned in the foregoing paragraphs are correct, their interpretation is difficult because the older experiments were not performed with isoelectric gelatin or fibrin, nor was the hydrogen ion concentration of the solutions determined As mentioned above, Loeb has shown that proteins combine stoichiometrically with acids and alkalis

But the different salts are very unequally effective in this regard If we compare a series of equimolecular salt solutions, say sodium salts, and at a concentration that we are likely to encounter under physiological or pharmacological conditions, it is found that these arrange themselves in a characteristic order The chlorid, bromid, and nitrate reduce the swelling of gelatin or fibrin in an acid solution less than do the sulphocyanate iodid or acetate, and these less than the sulphate, phosphate tartrate, or citrate If, on the other hand, we compare a series of salts having a common acid, say a series of chlorids, the metallic elements in these salts assume a characteristic order Ammonium, potassium, and sodium stand near each other, far more powerful than these are magnesium, calcium, barium, and strontium and yet more powerful are copper and iron

When compared with the powerful effects of the electrolytes, the non-electrolytes have but little effect in reducing the swelling of gelatin or fibrin in an acid solution The amount of water absorbed by a given mass of gelatin or fibrin in a given concentration of acid is practically uninfluenced through the addition of urea or ethyl or methyl alcohol This is also true of glycerin, dextrose, saccharose etc, in the lower concentrations, though in higher concentrations these inhibit the swelling of protein colloids in an acid medium The same is true of the effect of non-electrolytes on the swelling of gelatin or fibrin in an alkaline medium The reason why we lay stress upon the behavior in an acid medium is because we are chiefly interested in the carnivora, and the whole chemistry of these animals tends to run the reaction of their tissues over toward

A practically identical series of findings has been established for the effects of alkali and of alkali plus various electrolytes and non-electrolytes on liquid protein

It is readily apparent from these remarks that the changes in the viscosity of a liquid protein and the absorption and secretion of water by gelatin or fibrin under identical conditions parallel each other The fundamental change underlying both may, therefore, be looked upon as being the same We shall call it a *change in the hydration capacity of protein colloids* What makes our gelatin or fibrin swell increases the viscosity of serum albumin and vice versa What increases the hydration of a colloid increases the intimacy of its relation to its solvent and so the stability of the colloidal solution It will not surprise us therefore to have it pointed out that those conditions which increase the hydration capacity of the protein colloids are the conditions which increase this stability, while conversely those which decrease this must favor the precipitation and coagulation of the protein A few illustrations of the behavior of protein toward various precipitants and coagulants will make this clearer

The pure serum albumin already discussed is readily precipitated by heat or through the addition of alcohol When a little acid is added to the blood serum the hydration capacity of the colloid is increased and corresponding therewith its precipitability through heat or alcohol is lost But if yet more acid is added the hydration optimum for the protein is exceeded, and now the heat and the alcohol again regain their power to precipitate the protein In a similar way the protein that has lost its precipitability through heat by having an acid added to it has it restored when any salt is added just as we previously found this to decrease its hydration capacity

In this way we see how a series of reactions in certain protein colloids which at first sight seem to have nothing to do with each other all come to be reducible to a comparatively simple series of changes And so we also see how apparently widely separated and unrelated physiological, pathological and pharmacological phenomena all come to be the expressions of the same simple underlying colloid truths The mercury salt that kills bacteria makes the tears flow and maybe blinds an eye that kills in the same way some of the intestinal flora produces a diarrhea and perhaps a coagulation necrosis of the mucous membrane, is only an electrolyte that is peculiarly powerful in making the hydrated protein colloids which we find in the body give up their water and suffer the optical and solubility changes that go with this process And the changes that characterize a glaucoma a nephritis or a generalized edema are in the main only the expression of an increased hydration capacity of the tissue colloids involved and can be relieved by using those same electrolytes which we found especially effective in decreasing the hydration

fore, how such a solution of a protein colloid behaves under various external conditions. For an answer to this question we are especially indebted to Franz Hofmeister, Wolfgang Pauli, W. B. Hardy, P. von Schroeder, Hans Handovsky and K. Schorr. When we deal with such liquid colloids we cannot use the characteristics that served us in a study of gelatin and fibrin. The absorption of water, for example, by a gelatin plate can be accurately followed by weighing the plate, in the case of fibrin we can measure the height to which weighed quantities of this substance rise in glass tubes of a standard diameter. In the case of a colloidal solution we may use changes in its viscosity, changes in its precipitability or coagulability under the influence of heat or various electrolytes and non-electrolytes, or changes in its optical behavior. While we shall learn later that all these are measures of the same type of change in the colloid, these properties are individually of such great biological and therapeutic importance that their individual discussion is not without value. A change in the viscosity of the blood constitutes one of the great variables in the circulation which determines how much work the heart must do to keep this fluid circulating; precipitability and coagulability of the liquid colloids of the body are associated with the production and absorption of corneal opacities, the changes incident to exposure of parts of the body to heat and cold, the phenomena of blood and lymph coagulation; the optical properties of a colloid solution are associated with the maintenance of the normal and the establishment of abnormal indices of refraction in the clear media of the eye.

Wolfgang Pauli has studied a very pure liquid albumin by working with blood serum from which the various admixed crystalloids have been removed through long dialysis of the blood against distilled water. Such a solution is perfectly clear and entirely stable. If the viscosity of such a preparation is measured it is found to be considerably higher than that of pure water. If a trace of acid is added the viscosity is enormously increased. But to this there is an upper limit. In the case of such acids as hydrochloric, hydrobromic, nitric, or sulphuric a point is finally reached where a further increase in the concentration of the acid does not further increase but decreases the viscosity. For the weaker organic acids no such optimal point has yet been found.

The addition of any salt to an acidified albumin markedly reduces the viscosity. The addition of a non-electrolyte is conspicuously less effective in this regard. With the same salt the degree of reduction of the viscosity increases with every increase in the concentration of the added salt. With a given concentration of any series of salts very different effects are obtained. So for example, when sodium salts are compared, the chlorid, nitrate, and sulphocyanate are found to be less powerful in reducing the viscosity of an acidified albumin solution than the acetate or sulphate.

A practically identical series of findings has been established for the effects of alkali and of alkali plus various electrolytes and non-electrolytes on liquid protein

It is readily apparent from these remarks that the changes in the viscosity of a liquid protein and the absorption and secretion of water by gelatin or fibrin under identical conditions parallel each other The fundamental change underlying both may therefore, be looked upon as being the same We shall call it a *change in the hydration capacity of protein colloids* What makes our gelatin or fibrin swell increases the viscosity of serum albumin, and vice versa What increases the hydration of a colloid increases the intimacy of its relation to its solvent and so the stability of the colloidal solution It will not surprise us therefore to have it pointed out that those conditions which increase the hydration capacity of the protein colloids are the conditions which increase this stability, while, conversely those which decrease this must favor the precipitation and coagulation of the protein A few illustrations of the *behavior of protein toward various precipitants and coagulants* will make this clearer

The pure serum albumin already discussed is readily precipitated by heat or through the addition of alcohol When a little acid is added to the blood serum the hydration capacity of the colloid is increased and corresponding therewith, its precipitability through heat or alcohol is lost But if yet more acid is added the hydration optimum for the protein is exceeded and now the heat and the alcohol again regain their power to precipitate the protein In a similar way the protein that has lost its precipitability through heat by having an acid added to it has it restored when any salt is added, just as we previously found this to decrease its hydration capacity

In this way we see how a series of reactions in certain protein colloids which at first sight seem to have nothing to do with each other all come to be reducible to a comparatively simple series of changes And so we also see how apparently widely separated and unrelated physiological, pathological and pharmacological phenomena all come to be the expressions of the same simple underlying colloid truths The mercury salt that kills bacteria makes the tears flow and maybe blinds an eye, that kills in the same way some of the intestinal flora, produces a diarrhea and perhaps a coagulation necrosis of the mucous membrane, is only an *electrolyte that is peculiarly powerful in making the hydrated protein* colloids which we find in the body give up their water and suffer the optical and solubility changes that go with this process And the changes that characterize a glaucoma a nephritis or a generalized edema are in the main only the expression of an increased hydration capacity of the tissue colloids involved, and can be relieved by using those same electrolytes which we found especially effective in decreasing the hydration

of these same body proteins upon which any one may work in his laboratory

EFFECT OF COLLOIDS ON CRYSTALLOIDS

The previous paragraphs dealt in the main with the effect of various external conditions, notably various crystalloids, upon the state of the colloids that are of importance in the body. We wish now briefly to point out the fact that *colloids also affect the state of the crystalloids* that are brought in contact with them. So many problems in pathology and preventive medicine are associated with changes in the solubility characteristics of various substances found in our tissues and their secretions, that a brief reference to this problem is not out of the way. Not only is a normal or abnormal formation of bone a problem of this character, but so is the formation of concretions in the brain, in the gall bladder, in the kidney or bladder, or the deposition of urates, etc., in the joints.

Wolfgang Pauli and M. Samec have made a careful study of the solubility of various substances in colloidal protein solutions as compared with the solubility of these same substances in water. In general it may be said that the solubility of easily soluble electrolytes is slightly decreased through the presence of colloid material, while the solubility of difficultly soluble substances is, on the other hand, often very decidedly increased by this means. The removal or a change in the state of the colloid constituents of a body tissue or a body fluid, be this wrought through bacteria, a dietary regime or a pharmacological preparation, may, therefore, be followed by consequences which, on the one hand, determine the relief of a rickets, the prevention of an attack of gout or the prevention of the formation of a new set of kidney stones, on the other, by the hastening of an arteriosclerotic process, or the deposition of more urates, bile salts, or earthy phosphates in the form of stones.

SURVEY OF APPLICATION

We have laid special stress thus far upon the application of an isolated number of physicochemical conceptions to the individual cell. We have now to discuss these conceptions from the standpoint of groups of cells, for instance, as in such a multicellular organism as man. We will find that the same laws are operative here, but some have acquired an exaggerated importance, while others are hidden behind the complicating circumstances that spring out of the fact that the cells exist no longer individually, but in groups, and that special arrangements have been introduced to make life in such large groups possible. We no longer

deal with the individual, but with the society made up of individuals and, while the physiology of the whole is still only the compound physiology of the individuals, these individuals have so specialized in their work and have introduced such new schemes into their collective life, that this at first sight seems different from that of the individual who went to form the society But it is not A second fact that must have become apparent is that we have not been able to hold closely to our subject of therapy but that we have found it necessary to move rapidly and easily between the realms of pure chemistry and physics and those of physiology pathology and pharmacology The reasons for this are obvious No real distinction exists between these realms A therapy that involves discussion of so simple a matter as the role of sodium chlorid in the diet cannot be handled in any isolated way we must know the role played by sodium chlorid and the theory of its action in normal physiology before we can intelligently discuss the effects of its elimination or its addition to the diet under physiological or pathological conditions

Let us now see what use may be made of the principles discussed in the preceding pages when we deal with so complex an organism as man We will begin with the role of water in our everyday therapeutic procedures, for as we shall find behind the biochemical behavior of water there is many a problem that at first sight appears to have nothing to do with this

Role of Water—We ordinarily take the metabolism of water in the body largely for granted According to his desires, the normal individual consumes per day several liters of water or liquids containing water and after a comparatively short latent period he again eliminates this water in the form of urine sweat or through the breath Water has gone into the body and come out again, and the body is to all intents and purposes unchanged And this is why we are so likely to ignore entirely this most important function

From these simple statements let us remember first of all that we get a urinary output (or an output of water from the lungs or the skin if the temperature is high) that is proportional to the amount of water consumed The fact that the law of the conservation of matter and energy works for water as for any other substance introduced into the body is overlooked all too often in our daily practice When we wish more urine (or sweat) we must give more water and other things being equal we shall get this in proportion to the amount of water consumed While a cry for more urine is heard daily in every hospital the fact that we can obtain it only by giving more water to our patient is as constantly ignored Only water will yield more urine It is the one and only diuretic The substances that we call diuretics are such only because they aid in supplying water, as we shall see shortly

The loss of balance between the intake of water and the elimination

of water from the body represents a pathological state When water is retained in the body we call it edema The opposite state is represented by an abnormal loss of water from the body, and is not so much discussed Why has the normal body so constant a content of water, and what has happened when a patient has developed an edema or lost an abnormal amount of water? What principles must guide us in the treatment of the two last named conditions?

The absorption and secretion of water by all cells and tissues that have been examined thus far have been found, point for point, to be identical both from a qualitative and a quantitative viewpoint, with the absorption and secretion of water by such protein colloids as fibrin, gelatin, or serum albumin Our ameba has a certain size under normal conditions in its pond water This is identical with the amount of water absorbed by a flake of fibrin placed in ordinary water If we add a little acid to the pond water the ameba swells, or, if we add salt, it shrinks This again is identical with the behavior of the fibrin flake in a dilute acid or in a solution of salt

A complex organism like a human being behaves in toto like the ameba Under normal circumstances it has a certain water content which we cannot increase or decrease by the giving of water alone, any more than we can increase the amount of water held by the ameba by increasing the size of the pond in which he swims

The human body is a system of colloids that is saturated with water, and mere water drinking for example, will not increase the amount of water these colloids will take up

How can we produce an edema? We can produce this only by increasing the capacity of the tissue colloids for water, so that when water is offered to them they will swell The conditions that will thus increase the water capacity of colloids are various In the case of the protein colloids we found that acids are particularly potent, and so are the various proteolytic enzymes Under the influence of an abnormal acid (or an accumulation of other substances that are capable of increasing the hydration capacity of the tissue colloids) we might therefore if a source of water is available, expect to have a water retention occur The body colloids will swell, in other words an edema will result That such is the case has been proved by many experiments Not only will injection of acid into an animal lead to the development of a generalized edema, but the various conditions that are known to lead to a water retention in the body are all such as have associated with them an abnormal production or accumulation of acid in the tissues, as, for example, heart disease, respiratory disease blood vessel disease, passive congestion, intoxication with anesthetics intoxication with certain metals, intoxication with the toxins of many infectious diseases etc On the other hand, we have learned methods by which we can decrease the capacity

of the tissue colloids for water So notably, we found that the various salts are active in this regard We have normally a certain salt concentration in the body If we increase it the tissues give up water and the whole body loses weight, exactly as does our ameba when we drop him into a salt solution of a higher concentration than pond water In the same way we lose water if hypertonic salt solutions are injected into our blood vessels, if we take a cathartic salt or if we try to subsist on sea water

An abnormally high or low water content may involve the whole body or it may involve predominantly only a single organ or set of organs It may last a long time as in elephantiasis or only a short time as in the loss of water following a cathartic The abnormally high water content of various organs has on the whole the greater interest This is the prominent sign in many a specially named pathological condition So, for example, in the edema that affects the eye (which we call glaucoma), in that which affects the kidney (which we call nephritis), in that which affects the parenchymatous organs (which we call cloudy swelling) The important point in all this, from a therapeutic basis is that just as we can reduce the normal water content of cells and tissues by various salts, so can we reduce an abnormally high water content in these edematous states and by the same means The saline cathartic that makes the normal body give up water will also make the edematous body or organ give up water, and here we have a rational explanation of the beneficent effects of the long-established therapeutic use of these cathartic salts in edema But the explanation of how they act has been lacking We have been in the habit of saying that a cathartic salt makes for a secretion of water into the bowel and so for a loss of water from the edematous tissues It is more correct to say that the salts diffuse into the tissues, which then liberate water This 'free water comes out either through the bowel or through the kidneys And now we see too why the saline cathartics have so long been identical with the saline diuretics They act on the tissues with which they come directly in contact (bowel and kidney) and they also act on all the other tissues of the body an action quite as important as that on the bowel and kidney alone for only in this way is free water rendered available for elimination by these secretory organs (see page 43)

The electrolytes all decrease the capacity of the tissue colloids for water As sodium chlorid is one of these we shall be unable to subscribe to the idea that a restriction of this salt in the diet is right when we are trying to reduce the edema in a patient Sodium chlorid should on the contrary be urged upon the patient in his food between meals and if necessary it should be given him by rectum or intravenously

Whether we deal with a generalized edema or with a local one the principles underlying its relief are always the same Therefore we shall

not be surprised to find that, just as sodium citrate will make the intestinal mucous membrane give up water, it will also, when injected subconjunctivally, make a glaucomatous eye give up water, so relieving the glaucoma Or, if a kidney has ceased to functionate because of a pregnancy intoxication or the action of an anesthetic or the toxin of an acute infectious disease, this may usually be relieved by injecting sodium chlorid (and sodium carbonate to neutralize acid) intravenously in hypertonic solution This makes the kidney colloids shrink, and the decrease of swelling allows the kidney to get a normal blood supply once more By acting upon the edematous brain, the edematous optic nerves, and the body tissues generally, it reduces the headache, vomiting blindness and the edema of the body tissues generally At the same time the water freed in this way becomes available for urine, and the urinary output rise

While treatment of diseases associated with edema may be attended frequently with success when conducted according to the principles outlined in the preceding paragraphs, certain reservations should be mentioned The mechanism which maintains the acid base equilibrium in the body so constantly at a reaction between 7 8 and 7 0 can admit of no acid changes within the cellular systems in any way comparable to those employed in the gelatin and fibrin swelling experiments That changes in pH within the cell, outside the range maintained in the blood and body fluids may occur is possible, and may in turn account for certain dropsical conditions encountered in medical practice Furthermore, we should not lose sight of the fact that no matter how much sodium bicarbonate we may take by mouth, or intravenously, the pH of the blood and body tissue remains nearly constant, also in practice we rarely find cases with edema that have the bicarbonate content of the blood markedly reduced If we grant that within cells a more acid reaction may develop than is found in the body fluids in general, the neutralization of this acid may be supposed to take place more readily when the concentration of bicarbonate is raised thereby leading to greater penetration power on the part of the alkali We are not yet ready to admit of the general application of principles outlined, for it is a matter of clinical experience that certain cases of renal disease with edema are made worse when large amounts of salt, bicarbonate and water are given, instead of restriction of these substances

In this connection it is well to emphasize two more points The first of these is the reciprocal relationship that exists between the various secreting organs of the body Since the *sine qua non* of every secretion is the obtaining of free water, it is clear that, if we use this up for one secretion, we cannot have it for another—a point that is frequently lost sight of If we wish to have urine from a kidney we cannot expect it if we are robbing the body of all its free water by sweating our patient

(unless we cover this by giving water) or, if we are robbing the body of water through a secretion into the bowel we cannot at the same time have the water for urinary output or sweat

If these physicochemical conceptions are correct, then we have also an insight into the diuretic' action of various pharmacological products The caffein derivatives and digitalis will serve as good examples We have already emphasized the fact that only 'free water goes to the formation of any secretion These diuretics can act therefore, only because they furnish free water This they do by increasing the force or the frequency of the heart beat and the depth and rapidity of respiration In this way there is kept in contact with the body tissues a blood higher in oxygen and lower in carbonic acid than is the case when these drugs have not been taken By this means the normal (or abnormal) acid content of the tissues is reduced in consequence of which the hydration capacity of the tissue colloids is decreased 'Free water is then given off to the blood, which may then escape as urine (or as some other secretion)

Conversely, we may expect a drop in all the secretions and a retention of water if we give any drug that has an opposite effect The anesthetics, alcohol in large amounts atropin morphin etc are examples of this class These all permit a greater than normal accumulation of carbonic (and other) acid in the tissues and correspondingly they will decrease the output of urine create thirst lead to constipation, check sweating etc At the same time we learn from these simple facts that a reciprocal relation exists between the matter of water absorption and water secretion—the one is a mirror of the other, and that which favors the one at the same time hinders the other

What we have said holds for the ill as for the well body In concluding these paragraphs it is only necessary to point out that while in the ameba we deal with a mass of colloid material so small that secretion or absorption affects the whole this does not follow in the case of so large a colloidal mass as the human being Here one organ or set of organs may be busily absorbing water, while another is equally busy giving it up A few words regarding this are of therapeutic interest

The problem involved is clearly presented to us under physiological conditions in that almost any amount of water we choose to consume is absorbed from our intestinal tract while an equal amount (skin and lungs ignored) is given off by the kidneys What is the mechanism that accomplishes this?

Let us first ask what happens to the swallowed water and how it goes to form urine What have these problems to do with our ameba swimming about in its pond?

We have already paralleled the general processes of water absorption

and water secretion in the ameba with the behavior of a fibrin flake under similar conditions The ameba is a spherical mass of colloidal material that is saturated with water, and, through changes in its physicochemical surroundings, or through direct changes in its own chemical composition, it at times takes up water (absorption), at times gives up water (secretion) But in a multicellular organism the phenomena of water absorption and secretion that confront us do not at first sight seem to be interpretable on any such simple basis as that outlined for the ameba In man, for example we find whole organs set apart, and seemingly endowed only with powers of absorption, while others are apparently set apart to functionate only as secretory organs It becomes hard for example, to see just what relationship exists between a mucosal cell of the small intestine, concerned almost exclusively with an absorption of water from the lumen of the gut, or a kidney cell concerned equally exclusively with a secretion of urine, and the ameba which now absorbs and now secretes water either in response to its own physiological demands *or under the conditions with which experimentally we are pleased* to surround it And yet on closer analysis the difference between the two is not so striking

First of all we appreciate the fact that the mucosal cell is an absorbing cell only so long as we look at it from the side of the lumen of the gut If we regard it from the blood vessel side it is a secreting cell, for what it absorbs from the gut it gives up to the blood Similarly, the kidney cell is a secreting cell only because we usually look at it from the point of view of being a producer of urine, as a matter of fact, everything that goes to make up the normal urine was absorbed from the blood But, even if we look at the matter from the narrower point *of view the intestinal cells under certain circumstances become secreting* cells, in that they secrete substances into the lumen of the intestines, and, according to judgment of some authors, certain kidney cells may reabsorb materials that have been secreted by others In essence, therefore secretion and absorption in the higher animals are not different from absorption and secretion as observed in an ameba That which remains, therefore, to characterize absorption and secretion in the higher animals is merely this that, under normal circumstances and from the point of view of the organism as a whole, absorption and secretion occur predominantly in one direction What require special analysis are the conditions existing in the multicellular organism which make it possible for certain cells and tissues thus to act predominantly as absorbing systems, while others act predominantly as secreting systems

Let us see if we cannot define in general terms what must be the conditions lying at the bottom of this predominant functioning of certain cells and tissues in one direction, and do so on the basis of our belief

that the colloidal constitution of the living cell is primarily responsible for the phenomena of water absorption and secretion by the cell

The ameba, or an isolated cell or tissue derived from a higher animal kept in a solution of any kind is surrounded by this solution on all sides Could we imagine the chemical processes within these cells held in abeyance, then we could see how these cells would after a time get into a state of equilibrium with their surroundings When this is brought about the cells neither absorb nor secrete water Only as this equilibrium is disturbed, either through changes in the surroundings of these cells or through the specific chemical changes occurring in the cells, can we expect a renewed absorption or secretion

Under quite different conditions do we find the individual cells of the multicellular organism existing in the intact living body While in a certain sense the internal activities of the ameba may be compared with those of the individual cells making up say, the intestinal mucosa and there exists a certain analogy between the fact that both are surrounded by a liquid medium, with this the analogy stops For while the ameba is surrounded on all sides by the same liquid medium the cells of any of the absorptive or secretory organs found for instance, in a mammal are with different parts of their cell protoplasm, in contact with entirely different media The cells constituting the intestinal mucous membrane are bathed on the one side by intestinal contents, while on the other they are bathed by blood or lymph or both together Such cells, like any other absorptive or secretory cells similarly situated, are, therefore in the predicament of trying to get into equilibrium with as many different media as surround them It is in trying to do this that all the phenomena which we call absorption and secretion in the higher animals are produced It is during its attempt to get into equilibrium with the intestinal contents on the one side and the blood on the other that the mucosal cell (better the colloidal membrane separating the intestinal contents from the blood) absorbs the intestinal contents and transfers them to the blood

The body of a multicellular organism such as a mammal is like the individual ameba built up of colloidal material, which in the resting state is saturated with water To be counted in with the colloidal structures that make up this water-saturated colloidal system of the mammal and composing an integral part thereof are the blood and the lymph The entire system will not take up more water, nor give up any, except as chemical changes are first produced in it which either increase or decrease the capacity of the tissue colloids for water

The relationship between the absorption of water from the intestinal tract and its secretion subsequently by the kidney is easily understood when the following is borne in mind The cells of the small or large intestine will absorb water only if they are not already saturated with

water In consequence of the carbonic acid production in the cells, they are rendered capable of taking up water from the intestinal lumen But, as the blood circulates through the intestinal mucous membrane, the carbonic acid diffuses over into it Two changes follow this first, the capacity of the colloids in the mucous membrane to hold water is diminished, and, secondly the capacity of the blood (which we have said represented a water saturated colloidal solution) to take up water is at the same time increased A minimal calculation shows that a liter of blood in passing through the intestinal tract, where it changes from arterial to venous blood is made capable in this way of taking up at least 17 5 cubic centimeters of water As long as the circulation is maintained, and as long as the cells produce carbonic acid, the intestinal tract must therefore, absorb water if this is made available by being in the lumen of the gut Evidently the higher the carbonic acid (or other acid) content of the blood, the better absorbing medium for water must it become And so we are not surprised to note that water is best absorbed from the large bowel where the blood has a most highly venous character and less well from the small intestine, where this is not so markedly true Water absorption from the stomach is scarcely possible, for this is so richly supplied with arterial blood that its acid content scarcely varies

Just the reverse conditions are necessary if we are to obtain a secretion of water A secretion can be gotten only from arterial blood, that is to say blood low in carbonic (or other) acid The venous blood, which has grown rich in carbonic acid and water in its passage through the intestine loses the carbonic acid (as CO) when it passes into the lungs When this happens the colloids of the blood can no longer hold all the water they had absorbed so it becomes "free" This arterial blood with its free water passes to the kidney, and here the free water is eliminated as urine

We are not surprised on this basis to find that during absolute starvation the secretion of urine ceases (practically) entirely If the colloids of the body as a whole are saturated with water, none is left over to be secreted Only as the tissues undergo a gradual consumption during starvation, *or their colloids suffer changes which decrease their capacity* for holding water, is any liberated to become available for secretion

On the other hand, as we have already pointed out, if an animal that has its body colloids saturated with water consumes a quantity of water, after a time an amount of urine (or sweat or breath moisture) is secreted which is equivalent to the amount that has been drunk It does *not matter* how this water was introduced into the organism It may have been swallowed or introduced through a stomach tube into the gastro intestinal tract, or it may have been injected into the peritoneal cavity, under the skin, or directly into the blood But let it be noted that

the diuresis occurs only in proportion to the amount of "free" water present, in other words, as water not combined with a colloid

The correctness of these ideas is at once proved when we make the experiment of injecting intravenously in place of a physiological salt solution an equal volume of a solution in which the water is not "free" but combined with a colloid (that is in the form in which it exists in the body cells and fluids normally) Under such circumstances no increased water secretion in the form of urine (or sweat) results When blood or blood serum or a gelatin solution is injected intravenously no increased urinary output follows

These facts are of considerable therapeutic worth We have emphasized the fact that, if we would get any urine (or sweat) from a patient we must first have all his tissue colloids saturated with water After this has been accomplished we shall obtain from him a urinary (or sweat) output only as we have administered water over and above the amount necessary for the saturation of all his colloids Then we shall have a urinary output that is in proportion to the amount thus introduced The blood is not that fathomless well for urine that many clinicians imagine it to be

Let us ask now what happens so far as urinary secretion is concerned, if we introduce with a given quantity of "free" water varying amounts of any salt In discussing the absorption of water by protein colloids we found that all salts decrease the capacity of these colloids for holding water We are not surprised, therefore to note that if we inject progressively stronger sodium chlorid solutions intravenously we get (with a constant amount of water injection) a corresponding increase of urine It is ordinarily said that such salt solutions "stimulate" the kidney Aside from the fact that the word *stimulation* means nothing this is too narrow an interpretation of the case As we give progressively stronger salt solutions, we increase more and more the concentration of salt in the body tissues which then give up water This water is "free" and adds itself to the free water that we have introduced therefore we have a greater amount available for secretion as urine, sweat etc

While sodium chlorid makes a protein colloid give up water, other salts like sodium phosphate, sodium sulphate sodium citrate magnesium sulphate magnesium citrate etc act far more powerfully in this direction It is because of this more powerful action that they are called the saline diuretics Their behavior is to be explained in the same way as the behavior of sodium chlorid—they make the tissues of the body yield up water

The list of these saline diuretics is identical with the list of the saline cathartics The reason for this is obvious The saline cathartics do to the gastro-intestinal tract what they do to any protein colloid as F Hofmeister first showed In spite of the many complex explanations

of the action of the cathartic salts that have been advanced since Hofmeister's work, we are destined to accept his explanation

We have now to look at our problem from another point of view While sometimes we desire the body colloids to give up water, nature at times furnishes pathological conditions in which we desire just a reverse result

We can illustrate what is meant by referring to the problems presented by such conditions as hemorrhage and shock The two conditions *are mentioned in the same sentence not alone because, from a clinical* standpoint, they have much in common, but because this is also true from a therapeutic standpoint In both we have a diminution in the volume of the circulating blood, and a good part of the therapy of these conditions consists in combating this sign by attempting to increase the volume of the circulating blood The various therapeutic schemes that have been devised to accomplish this end are familiar to every one What are their relative merits?

It is at once apparent that the injection of salt solutions into such individuals can yield only temporary results We inject free water in this way, and free water does not remain in the blood vessels, but escapes in a short time through the various secretory organs of the body or is sucked into the tissues which, in hemorrhage or shock, are likely to have an increased capacity for water Only water in combination with a colloid will and can remain in the blood vessels, and hence the better results to be obtained by introducing, instead of salt solutions blood, blood serum or, if necessary, gelatin solutions

The same problem confronts us in the treatment of such a condition as constipation when due, as is so often the case to a too perfect absorption of water from the intestinal contents When we do not wish to prevent so perfect an absorption of water from the intestinal tract by giving cathartics which tend to make for a secretion of water into the bowel, then we can regulate the process by feeding material from which the intestinal mucous membrane cannot absorb the water It cannot do this if we keep the water in the intestinal contents bound to a colloid That is what happens when we prescribe a diet rich in cellulose or add to the ordinary diet such substances as agar agar, or the various Japanese sea weeds from which this is made Cellulose and agar agar are colloidal substances that have a great affinity for water, so they hold it in the gastro-intestinal tract in spite of the efforts of the colloids of the intestinal mucous membrane to get it out Because these colloids cannot get this water out, the intestinal contents remain soft, and so constipation is prevented

Absorption and Secretion of Dissolved Substances—We have purposely laid so much stress upon the question of water absorption and water secretion from the body because *the absorption and secretion of*

dissolved substances are intimately associated with and largely dependent upon this Not only does this hold for the normal absorption and secretion of such substances as serve as foods or represent metabolic waste products, but also it holds for the absorption and secretion of substances which, either from a quantitative or a qualitative standpoint are known to us as parts of our pharmacological or therapeutic armamentarium The general problems of *intoxication and detoxication* are found here

Let us first look at the problem as a whole

We have in the earlier parts of this chapter always emphasized the behavior of the individual cell The reason for this lies in the fact that the multicellular organism and its behavior represent merely the compounding of the behavior of many such cells and different kinds of cells So we shall not be surprised to find that everything we have said regarding the unicellular organism holds for the multicellular one except that in this certain additional factors are introduced which somewhat complicate the picture and demand separate analysis

But just as we were able in a rough way to look upon man for example, as a huge mass of colloidal material which collectively resembled the small mass represented by an ameba in its behavior toward water so similarly can we compare the large mass with the small in its behavior toward dissolved substances The ameba obtains all the various substances that it takes up from those which are dissolved in the water surrounding it and it rids itself of such dissolved substances as it may have in excess in its protoplasm to this same water surrounding it

A human being does in toto the same thing, only the mass of water available for such purposes seems comparatively small and the processes of absorption and secretion of dissolved substances seem to be more intimately associated with certain organs Thus we usually absorb a food or a toxic agent from an aqueous solution of this contained in the gastro-intestinal tract we rid ourselves of these same substances by giving off an aqueous solution of them that we call urine But the processes involved in these apparently complex acts are in essence no different from those which we encountered in our ameba

All the absorbing and secreting systems that we encounter in the human body may be roughly divided into three phases In the case of such an absorbing system as that presented by the intestine these are represented by (*a*) the material to be absorbed, (*b*) the absorbing tissue and (*c*) the blood or lymph In the case of a secreting system, such as is represented by the kidney we similarly recognize three phases (*a*) the blood or lymph (*b*) the secreting tissues (*c*) the urine

Let us take up first the matter of absorption and see what the general mechanism of this is in the case of the human being

When we take a meal or swallow a drug it is practically equivalent to saying that we take an aqueous solution of something This aqueous

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dissolved substances are intimately associated with and largely dependent upon this Not only does this hold for the normal absorption and secretion of such substances as serve as foods or represent metabolic waste products, but also it holds for the absorption and secretion of substances which, either from a quantitative or a qualitative standpoint are known to us as parts of our pharmacological or therapeutic armamentarium The general problems of *intoxication and detoxication* are found here

Let us first look at the problem as a whole

We have in the earlier parts of this chapter always emphasized the behavior of the individual cell The reason for this lies in the fact that the multicellular organism and its behavior represent merely the compounding of the behavior of many such cells and different kinds of cell So we shall not be surprised to find that everything we have said regarding the unicellular organism holds for the multicellular one, except that in this certain additional factors are introduced which somewhat complicate the picture and demand separate analysis

But just as we were able in a rough way to look upon man for example, as a huge mass of colloidal material which collectively resembled the small mass represented by an ameba in its behavior toward water so similarly can we compare the large mass with the small in its behavior toward dissolved substances The ameba obtains all the various substances that it takes up from those which are dissolved in the water surrounding it, and it rids itself of such dissolved substances as it may have in excess in its protoplasm to this same water surrounding it

A human being does in toto the same thing only the mass of water available for such purposes seems comparatively small and the processes of absorption and secretion of dissolved substances seem to be more intimately associated with certain organs Thus we usually absorb a food or a toxic agent from an aqueous solution of this contained in the gastro-intestinal tract we rid ourselves of these same substances by giving off an aqueous solution of them that we call urine But the processes involved in these apparently complex acts are in essence no different from those which we encountered in our ameba

All the absorbing and secreting systems that we encounter in the human body may be roughly divided into three phases In the case of such an absorbing system as that presented by the intestine these are represented by (*a*) the material to be absorbed (*b*) the absorbing tissue and (*c*) the blood or lymph In the case of a secreting system, such as is represented by the kidney, we similarly recognize three phases (*a*) the blood or lymph, (*b*) the secreting tissues (*c*) the urine

Let us take up first the matter of absorption and see what the general mechanism of this is in the case of the human being

When we take a meal or swallow a drug it is practically equivalent to saying that we take an aqueous solution of something This aqueous

solution may contain colloids (such as our ordinary foods, the starches, proteins, and fats), or crystalloids (such as salt, cane sugar, strychnin hydrochlorid, or Fowler's solution) This is the first phase of our absorbing system

The second is a colloid membrane that is made up of all the structures lying between the solution of substances to be absorbed and the blood or lymph This colloid membrane is, therefore, a fairly firm structure, like a water-soaked leaf of gelatin Only it may not be so entirely homogeneous For instance, we recognize the differences that may result from having different kinds of cells in this absorbing membrane, and then between the different cells there may lie intercellular substances that need not be identical with the material that builds up any or all the various cells found here But for the sake of simplifying our argument let us imagine it to be entirely homogeneous

The third phase in our absorptive system is represented by the blood This is also made up of colloidal material, but it is not solid, it is liquid It corresponds therefore, to a solution of gelatin

What must happen in such a system?

We have already discussed what must happen so far as the water contained in the first of these systems—that is, the water in the lumen of the gastro-intestinal tract—is concerned The next fact to be emphasized is that the absorption of this and the absorption of substances dissolved in it are two distinct processes *A solution is never absorbed as such*

Let us here interject that the mixture which we originally introduced into the gastro-intestinal tract undergoes a simplification to this extent all the various colloids that may have originally been in it are converted into crystalloids before they are absorbed From an academic standpoint this is not strictly true but for practical purposes it is The colloidal proteins are converted into amino-acids, the colloidal carbohydrates into dextrose, the colloidal fats into fatty acid and glycerol, colloidal drugs are converted into crystalloidal form, etc

Whenever a solution is seen to be absorbed we are observing the composite of the absorption of the solvent plus the absorption of each individual substance dissolved in that solvent For example, when any solution is introduced into the intestine, each one of the dissolved substances diffuses into the wall of the intestine until an equilibrium is established in the distribution of each of these substances between the liquid phase represented by the solution and the more solid phase represented by the (colloidal) intestinal wall Similarly, every substance present in the intestinal wall tends to diffuse out into the solution to the establishment of an equilibrium In biological material it has been very generally assumed that the distribution of dissolved substances between two such phases attains an equilibrium when the concentration of

any dissolved substance is the same in both Such an a priori conclusion is entirely unjustified We deal in this problem with the distribution of a dissolved substance between water and a colloid and, as we know from the facts now available on this subject equilibrium may be reached when the dissolved substance is contained in less the same or a higher concentration in the colloid than in the solution surrounding it

Now, while the absorptive membrane is trying to get into equilibrium with the solution to be absorbed on the one side, it is also trying to get into equilibrium with the blood on the other The problem of the 'selective' absorption of the dissolved substance is the problem of the agencies concerned in establishing an equilibrium between all the various dissolved substances in these three phases As we pointed out above the factors of greatest importance in such a problem are the character of the various colloids concerned and their physicochemical state, as determined through the presence of acid alkalis, salts and various non electrolytes the nature of the dissolved substances to be absorbed and their rate of diffusion the presence or absence of lipoids in the colloidal absorbing membrane and in the blood etc In other words, the laws of adsorption, of partition and of chemical combination are all at work Therefore, to the process of simple diffusion in this matter of absorption (or secretion) become added a number of secondary phenomena that obscure its purity But this does not make questionable the fundamental importance of diffusion itself in the process of both absorption and secretion

To illustrate let us try to follow the relatively simple process of the absorption of a strong (so-called hypertonic) sodium chlorid solution introduced into the intestinal tract (or into the peritoneal cavity, or under the skin) Both the water and the salt immediately begin to diffuse into the absorbing membrane As diffusion progresses the concentration of the sodium chlorid in the absorbing membrane rises This rise in concentration so affects the colloid of the absorbing membrane that they stop taking up water, or if it becomes sufficiently high, an actual secretion of water into the gut or peritoneum or subcutaneous tissues results While this is occurring, an equilibrium is tending to be established between the sodium chlorid in the solution undergoing absorption and the salt in the absorbing membrane but is never attained under normal circumstances because the salt in the absorbing membrane is at the same time trying to get into equilibrium with the sodium chlorid in the blood Now, since the blood is circulating it is evident that the equilibrium is constantly being broken down toward the side of the blood In consequence of this, more and more salt must move over into the blood (be absorbed) But as this goes on the colloids of the absorbing membrane again return to a more normal state and so the absorption of water, which could not occur before, can again take place

With a dilute (a hypotonic) solution of sodium chlorid, the water does not meet with so great a resistance to absorption, and it is possible for such a solution to become more and more concentrated as the water is (the more rapidly of the two) absorbed from it Even salt solutions isotonic with the blood must be absorbed We were never able to explain this on our old osmotic conceptions of water absorption, because no osmotic differences exist in such a case to make the water move, but on the colloidal basis there is no difficulty in interpreting what happens. Let the colloids of the absorbing membrane take a little water from the isotonic solution and salt must quickly follow, for now its concentration is no longer in equilibrium with the sodium chlorid in the absorbing colloidal membrane As the water passes over into the blood more water goes into the absorbing membrane, and then more salt until all is absorbed Or we can start the absorption by having a little salt go in first and then the water, etc, for, if the truth be told, we do not yet know just what characterizes the "isotonic" solution, nor shall we until the colloidal constitution of living matter has been adequately taken into account

As a final word let it be added that, on the basis of these colloidal conceptions of absorption we experience no difficulty in understanding why any solution remaining for longer periods in the intestine or in the peritoneal cavity may, while it is being "absorbed" have appear in it various substances found in the blood or tissues which it did not originally contain As dissolved substances diffuse out of a solution undergoing absorption into the absorbing membrane until an equilibrium is established, just so, of course must the substances contained in the absorbing membrane tend to diffuse into the solution

The fact will, therefore, not surprise us that, when a mixture of different dissolved substances is offered the intestinal mucous membrane for absorption, these substances are not all absorbed at the same rate or in the same relative proportions Neither are we surprised that the absorption is "selective" We should be more surprised if it were not The selective character of absorption depends upon the fact that the absorption of water and the absorption of dissolved substances are separate processes Of the dissolved substances each moves at its own rate and is influenced in its movement by factors that may not affect the others in the same way nor to the same degree

The mechanism of the *secretion* of dissolved substances is the mirrored reflection of what has been said, and may be best outlined by discussing the secretion of dissolved substances from such an organ as the kidney

What has been most difficult to explain in secretion has been its selective character, in other words, the ability of the kidney to separate from the blood a liquid which has a totally different quantitative and

qualitative composition Qualitative differences are for the most part explainable through chemical changes that occur in the secretory cells themselves whereby substances are produced (such as mucin, for example) which do not appear in the blood at all In other respects a secretion differs only in quantitative composition from the blood This may go to the point of having entirely absent from a secretion certain constituents of the blood, as, for example, albumin from the normal urine For the most part however the secretion contains some substances in higher, others in lower, concentration than the blood To limit ourselves again to the urine, we need by way of illustration only recall that under ordinary circumstances, the urine contains less chlorid than the blood and more sulphates and urea How are such differences to be explained?

To begin with, it is well to call to mind that a secretion of dissolved substances is possible only so long as water is furnished the living organism A secretion of water is necessary before we can hope to have any secretion of dissolved substances This is a physiological truth that is utilized daily by the intelligent physician when he orders the drinking of large amounts of water to aid the organism in ridding itself of any poison, as the toxin of an infectious disease for example How the secretion of water by the kidney may be made a continuous affair we have learned from our previous discussion How it must make for a continuous secretion of dissolved substance is apparent from what follows

Let us recall here our division of the urinary secretory system into its three parts the blood the secreting membrane, and the urine and our brief characterization of the first as a liquid colloid in which various crystalloids are dissolved of the second as a solid colloid also containing various crystalloids and of the third as a watery solution of various crystalloids (practically) free from colloids Thus far our discussion has shown that under the conditions normally existing in the body no water can be introduced into the blood without getting the secretion of an equal amount as urine And what is secreted as urine is water and only secondarily do substances come to be dissolved in it, so that it assumes a chemical composition which permits it to be characterized as urine Let us see now what must happen if some soluble (or pseudo-soluble) substance is introduced into the blood To simplify the problem and not make our discussion unnecessarily long let us think of the blood as one homogeneous system and the urinary membrane as another Under such circumstances one of the three possibilities presents itself from a physicochemical standpoint The dissolved substance may distribute itself uniformly throughout the blood and the urinary membrane or it may be present in either a greater or a less concentration in the urinary membrane than in the blood Just what will happen is dependent upon the nature of the dissolved substance and the physical and chemical composition of the blood and the urinary membrane at the time Of greatest

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centration of an acid by colloids from very dilute solutions of acid salt or acids has been proved directly

What we have said concerning the absorption of dissolved substances in the intestinal tract, and the secretion of dissolved substances by the kidney, may be applied with small variation to any other absorptive or secretory system that we find existing in the body It may be applied also to any of the processes of absorption and secretion as these involve any cell group of cells, or organ outside of those included in any special discussion of absorption and secretion When we deal with such an organ as the brain, the spleen or the adrenal, the system involved is really somewhat simpler than in the case of the intestine or the kidney The individual cells of these organs are more like the ameba in its pond water—they are more nearly surrounded on all sides by the same fluid medium, and from this medium (the blood or blood plasma which we call lymph) they absorb the substances necessary for their existence or harmful to it and similarly they give off to this medium their normal metabolic products or the substances which as toxic bodies may have gotten into them The whole problem therefore becomes in the main a distribution of dissolved substances between (roughly) two media, on the one hand the cells and their intercellular substances on the other the blood (or lymph)

The various normal and abnormal dissolved substances come to all the cells in the body through the same blood stream The cells endeavor to get into equilibrium with each one of these substances But, as the individual cells of the body differ from each other in chemical composition, or as the same cell is in a different physicochemical state at different times and under different conditions so will the different cells, or the same cell at different times, behave entirely differently toward the same dissolved substance or substances as these are brought to them in the blood It is for this reason that not only the rate at which any dissolved substance is taken up will be different for different cells or the same cell under different conditions but the absolute amounts taken up will also vary

From this we may understand why although one blood bathes all the body tissues one tissue is high in potassium while another is low, and while one takes up much calcium another refuses it almost entirely It is for this reason that the spinal cord takes up relatively more strychnin than any other tissue in the body that anesthetics go into the central nervous system that tetanus toxin picks out chiefly the peripheral nerves that when any vital stain is introduced into the body only certain tissues are deeply stained that when arsphenamine is given intravenously it is taken up chiefly by the (cells of the) spirochetes and to their destruction A specific poison like a specific cure becomes known to us whenever we discover some substance which, when offered the healthy or dis

importance are such facts as the presence and absence of lipoids, the character of the colloids concerned, and the state of these colloids as determined by the presence of acids, alkalis salts, or various non-electrolytes In other words, the laws of partition and the laws of adsorption again come into play These differences in the distribution of a dissolved substance between the blood and the urinary membrane are rendered strikingly apparent when dyes are used as the dissolved substances

But this distribution of a dissolved substance between the blood and the urinary membrane represents in the end only a *static* affair, and the secretion of dissolved substances in urine is a *dynamic* one It requires no special comment to see now why only through the continuous secretion of water from the kidney can a continuous separation of dissolved substance from the urinary membrane (secretion) be rendered possible The presence of water in Bowman's capsule and in the uriniferous tubules introduces the third phase into our secretory system and continuously breaks down the equilibrium that is trying to become established between the dissolved substance in the blood and the dissolved substance in the urinary membrane

The attempt to establish an equilibrium between the dissolved substances in the urinary membrane and the dissolved substances in the urine (originally only water), as it passes down the uriniferous tubules, makes for a diffusion of dissolved substances out of the urinary membrane Consequently as long as water is being secreted by the kidney this must tend to destroy the equilibrium which is trying to become established between the dissolved substances in the blood and the dissolved substances in the urinary membrane If we recall the physicochemical fact that, when any dissolved substance is offered simultaneously a liquid colloid, a solid colloid and water (as is the case in the kidney), an unequal distribution of the dissolved substance among the three phases is the rule, then we shall have no difficulty in understanding why a difference in quantitative composition between the blood kidney tissue, and urine, so far as dissolved substances are concerned, is also the rule Therefore, a "selective secretion is to be expected rather than to be wondered at

Further than this we cannot pursue this subject at present But in passing I should like to point out that the fruits of colloid chemistry help us to understand even the most radical differences that exist between secretions and their source None is perhaps more striking than the strongly acid reaction of the urine or the gastric juice against the practically neutral reaction of its source, the blood But even these can be accounted for through the selective absorption by the colloids of the urinary membrane of the sodium dihydrogen phosphate, and by the colloids of the gastric mucosa of the hydrochloric acid of the blood Such a con

done this unthinkingly, but because we feel that all those phenomena which are usually discussed under the heading of the osmotic phenomena of cells can more easily and more satisfactorily be explained on the basis of the colloidal constitution of living matter, and because we feel that the great mass of facts which has stood against the general applicability of the laws of osmotic pressure to cells can also be better explained on the colloidal basis We see no reason therefore, for calling upon a complicated osmotic system for further help But this point of view is not yet generally accepted in the biological sciences, and so we wish to summarize briefly some of the experimental and theoretical evidence usually adduced in favor of the osmotic conceptions of the absorption of water and dissolved substances in the body, examine it critically, and then briefly indicate how this may be used to better advantage in support of our colloidal conceptions of absorption

The widely divergent and contradictory 'osmotic conceptions of absorption and secretion as upheld by different workers at the present time had their beginning in the original osmotic investigations of DeVries and Pfeffer In order to account for the turgor (that is water content) of plant cells these authors held that the individual cells were surrounded by 'osmotic membranes of such a character that while they allowed water to pass through them, they did not permit substances dissolved in this water to pass through On this basis they explained the observation that plant cells swell up in water low in dissolved substances, and shrink in more concentrated solutions by saying that in the former case water is sucked into the cell while in the latter it is sucked out The movement of water into and out of the cell occurs until the (osmotic) concentration of dissolved substance is the same on both sides of the membrane postulated to exist about the cells But, in order to permit the water to move this membrane must be impermeable to dissolved substances (otherwise of course the dissolved substances would simply move from a region of higher concentration to one of lower concentration and so osmotic differences could not come to pass and consequently there would be no movement of water)

From these observations and theoretical views sprang the interest of the physical chemists in the whole problem of osmosis and so we see constructed the various osmotic cells that may be seen in any physicochemical laboratory Pfeffer was again pioneer here He conceived the idea of supporting the precipitation membranes' that Moritz Traube had described before him in the walls of a porous pot, in order to give them enough strength to withstand considerable pressure Such "precipitation membranes may be produced by the use of many different substances, but the best and commonest one is made by allowing the solution of a copper salt and the solution of a ferrocyanid to move into the wall of a porous pot from opposite sides They meet in the wall of the pot

eased human body, distributes itself in such a way between the various (colloidal) phases that make up the human body as to appear in a toxic concentration in the cell or organ under consideration before it does this in any other or all the other cells or organs of the body

It is well here to emphasize again the fact that intoxication at all times depends upon the *concentration* of the toxic substance present, and not upon the absolute amount given The whole principle of detoxication depends upon the recognition and use of this fact We can easily illustrate what we mean when we discuss the intoxication that goes with any acute infection Here we have an organism producing a poison at a fairly uniform rate Where we do not possess a specific therapy much of the art and science of treatment consists in keeping the concentration of this toxic substance as low as possible How do we manage this? When we cannot influence the factor of toxin production, we have only one way at our disposal, and that is to keep the concentration of the toxins as low as possible To do this we can do but one thing, namely, give water

As we noted above the giving of water makes for a secretion of water, and this secretion of water is necessary before we can get a secretion (washing out) of any toxic substance By washing the toxic substances out of the kidney cells, for example, we break down the equilibrium existing between the toxic substance here and that in the blood So more toxic substance will move from the blood over into the kidney to be eliminated *if the third phase is created by giving water* But when the toxic concentration in the blood falls, the toxins from the cells will move over into the blood, and the lower we can keep the toxic concentration in the cells the less the intoxication and consequent pathological effect upon them Now we also see the sense of giving water not only in a haphazard way as the patient may desire it, but in specified doses at regular intervals day *and night* Otherwise during the periods of water abstention the toxin concentration will run up What happens is illustrated by the variation in the concentration of the normal constituents eliminated in the urine in any twenty four hours Since we are accustomed to consume most water with our meals, the urine after our meals is pale and low in urinary constituents It is deep-colored and highly concentrated on rising in the morning, for through the night we do not consume any water

OSMOSIS AND QUESTION OF CELLULAR 'MEMBRANES

In our analysis in physicochemical terms of certain phenomena familiar to every worker in the art and practice of medicine we have almost ignored the much discussed question of osmotic pressure We have not

To-day we may safely say that we do not know a single cell for which the laws of osmotic pressure are valid

We need not go into details to prove this If cells obeyed the laws of osmotic pressure then they ought always to have the same volume in isosmotic solutions of different substances Exceptions to this conclusion are the *rule* Again, with every increase in the concentration of the medium surrounding a cell we should get a *proportional* decrease in the volume of the cell As a matter of fact, the shrinkage is always less than anticipated (Koeppe, Durig) While electrolytes and non-electrolytes are in our laboratory osmotic cells equally active when the same number of dissolved particles are present in the unit volume, this is not the case in living cells Generally speaking the electrolytes are active out of all proportion to the non-electrolytes when living cells are concerned How all these facts are readily explained on the colloidal basis has been pointed out above

To have the laws of osmotic pressure tenable for living cells we must have semipermeable membranes about them Only as this is the case can changes in osmotic pressure become available for the movement of water into and out of cells If for the sake of argument, we grant this conclusion then no dissolved substances can get into or out of the cell Such a conception of the cell is impossible for under such circumstances how could a cell get its necessary food, or how could it rid itself of its various metabolic products? To get around this difficulty various observers have made these osmotic membranes permeable to some or many dissolved substances But the moment we grant this we can no longer maintain differences in osmotic pressure and so water can no longer be absorbed The adherents to the view that osmotic membranes exist about cells can take their choice either they can utilize their conception in order to make water move or they can have these membranes permeable and so have dissolved substances move—but *they cannot have both*

An enormous literature has sprung up about this question of membranes surrounding cells From the original osmotic membranes of Pfeffer which were semipermeable we have come to those which are partially permeable and then to those which are permeable sometimes and then again not But even these complicated notions encounter trouble, for there is so little connection between the kind of substances that enter cells and those that do not Only the members of one group—that which has a ready solubility in the fats—have been recognized as having one property in common and to account for their ready entrance into cells the osmotic membrane about cells has been endowed with lipoidal characteristics The unfortunate part about this theory which is in essence that of E Overton is that while it renders easier our conception of the absorption of these lipoid-soluble substances it makes it impossible to get the ordinary salts and water into cells for these are not particularly

and a precipitate of copper ferrocyanid is deposited here The copper solution may now be washed out of the pot and the ferrocyanid rinsed off the outside In the wall of the pot remains a "precipitation membrane" of copper ferrocyanid This membrane allows water to pass through it easily, but it will not allow substances dissolved in this water to get through The membrane is "semipermeable," and therefore is identical in this property with the "osmotic" membrane that Pfeffer maintained surrounded the living cell If the laboratory cell is filled with a solution of any kind and is then placed in water, water is sucked into the cell, if it is placed instead in a more concentrated solution, water is sucked out of the cell As is readily apparent, this corresponds to what Pfeffer and DeVries observed in the case of the living cell

Pfeffer made many osmotic measurements with his laboratory cell, and, on the basis of his observations, van't Hoff some years later formulated his famous laws which are as follows

1 At constant temperature the osmotic pressure of dilute solutions is proportional to the concentration of the dissolved particles

2 At the same temperature equal volumes of all dilute solutions having the same osmotic pressure contain the same number of dissolved particles

3 At constant volume the osmotic pressure of any solution varies directly as the absolute temperature

The work and conclusions of van't Hoff and the physical chemists now became retroactive and the attempt was made to apply the laws of van't Hoff not only to the biological facts that DeVries and Pfeffer had furnished, but to the additional ones contributed by Hamburger, Gryns, Koeppe, Loeb, Hober, Overton, Webster, etc To this end the observations made on plant and animal cells were compared with those made with the laboratory osmotic cell When a solution of any electrolyte or non electrolyte was found not to change the volume of liquid in an osmotic cell, it was said to be "isosmotic" with the cell contents Equally concentrated solutions of all kinds were found to be isosmotic with the contents of the osmotic cell These were, therefore isosmotic with each other When a solution of any kind was found not to change the volume of any living cell it was said to be "isotonic" with the contents of this cell In this way the solutions of many different substances were compared and the "isotonic coefficients" determined in each case If the laws of osmotic pressure were active in living protoplasm, it was therefore to be expected that, if certain solutions were isotonic with each other, they should also be "isosmotic" with each other

When the first rough comparisons were made it was in fact thought that the isotonic solutions were isosmotic but this conclusion could not stand the pressure of more careful and more numerous observations

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An enormous literature has sprung up about this question of "membranes" surrounding cells. From the original osmotic membranes of Pfeffer which were empermeable, we have come to those which are partially permeable, and then to those which are permeable sometimes and then again not. But even these complicated notions encounter trouble, for there is so little connection between the kind of substances that enter cells and those that do not. Only the members of one group—that which has a ready solubility in the fats—have been recognized as having one property in common, and to account for their ready entrance into cells the osmotic membrane about cells has been endowed with lipoidal characteristics. The unfortunate part about this theory, which is in essence that of E. Overton, is that while it renders easier our conception of the absorption of these lipoid-soluble substances, it makes it impossible to get the ordinary salts and water into cells, for these are not particularly

soluble in the lipoids And yet we know from physiological and pathological facts that both must be able to get into cells

Moreover, what do we gain when we have succeeded in getting some dissolved substance or water through any membrane postulated to exist about a cell? It would collect here and we should still have to account for the movement of either the dissolved substance or the water into or through the rest of the cell protoplasm *There are no membranes about cells* neither of the lipoid type (Durig, Pauli, Fischer), nor of the 'osmotic' type (Fischer) All the phenomena which offer so much difficulty in explanation when we assume that membranes exist about cells are readily interpreted, without recourse to such postulates, on the basis of the colloidal constitution of protoplasm as we indicated above

In answer to these arguments some of our critics have retorted that a 'membrane' exists wherever two phases come in contact with each other At this point we have to stop and begin to define terms, for here the arguments begin to become academic. A drop of any fluid, a drop of any colloidal solution, a drop of protoplasm or a cell, has a "membrane' about it, but this membrane' is simply a surface tension film, it has nothing in common with the "osmotic membranes' that are in turn talked about by the botanists the physical chemists, and the original animal physiologists who worked in this field *These surface tension films are chemically identical with the rest of the cell protoplasm and* (except as colloidal particles tend to collect in these surface films and so raise the concentration of these particles here) *as such behave toward water or dissolved substances exactly as does the rest of the cell protoplasm*

We encounter differences in the absorption of water and of dissolved substances in the living animal as we pass from one (colloidal) phase to another Such different phases may be represented by different organs, different tissues different cells or intercellular substances, different parts of the same cells If such phase differences are ultimately shown to exist at the surface of cells they will assume an importance in this problem of absorption and secretion But this importance will be neither greater nor different in this problem, because the phase difference occurs at the surface of the cell, than if it had occurred anywhere else in that colloidal complex that we call living matter

The following bibliography is necessarily most incomplete, but the easily accessible references here given will readily put any one who consults them and who so desires in touch with the voluminous literature now available on these subjects

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The best general text available on colloids and their properties is

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Shorter general accounts of colloids and changes in their state may be found in

soluble in the lipoids And yet we know from physiological and pathological facts that both must be able to get into cells

Moreover, what do we gain when we have succeeded in getting some dissolved substance or water through any membrane postulated to exist about a cell? It would collect here and we should still have to account for the movement of either the dissolved substance or the water into or through the rest of the cell protoplasm *There are no membranes about cells* neither of the lipoid type (Durig, Pauli, Fischer), nor of the "osmotic" type (Fischer) All the phenomena which offer so much difficulty in explanation when we assume that membranes exist about cells are readily interpreted without recourse to such postulates, on the basis of the colloidal constitution of protoplasm as we indicated above

In answer to these arguments some of our critics have retorted that a "membrane" exists wherever two phases come in contact with each other At this point we have to stop and begin to define terms, for here the arguments begin to become academic A drop of any fluid, a drop of any colloidal solution, a drop of protoplasm or a cell, has a "membrane" about it, but this membrane is simply a surface tension film, it has nothing in common with the "osmotic membranes" that are in turn talked about by the botanists, the physical chemists, and the original animal physiologists who worked in this field *These surface tension films are chemically identical with the rest of the cell protoplasm and* (except as colloidal particles tend to collect in these surface films and so raise the concentration of these particles here) *as such behave toward water or dissolved substances exactly as does the rest of the cell protoplasm*

We encounter differences in the absorption of water and of dissolved substances in the living animal as we pass from one (colloidal) phase to another Such different phases may be represented by different organs, different tissues different cells or intercellular substances, different parts of the same cells If such phase differences are ultimately shown to exist at the surface of cells they will assume an importance in this problem of absorption and secretion But this importance will be neither greater nor different in this problem, because the phase difference occurs at the *surface of the cell* than if it had occurred anywhere else in that colloidal complex that we call living matter

The following bibliography is necessarily most incomplete, but the easily accessible references here given will readily put any one who consults them and who so desires in touch with the voluminous literature now available on these subjects

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CHAPTER II

NUTRITION AND DIETETICS

Warren Coleman

Revised by Edwin G Gross

Some knowledge of the laws of nutrition, as well as of dietetics, is requisite for the rational construction of dietaries, whether they be intended for persons in health or for those ill from disease.

Nutrition concerns the digestion and absorption of foods, the destinies and transformations of the foodstuffs after absorption, and the energy liberated within the body by their oxidation.

Dietetics on the other hand relates to the selection of foods the arrangement of dietaries which cover the nutritive requirements and, at the same time, conform to the likes dislikes and idiosyncrasies of persons, and the methods of preparing and serving the food.

A knowledge of the fuel values of foods is likewise essential to rational feeding. The body derives energy from food in much the same manner that an engine does from coal. The universal law of the conservation of energy holds for the body as well as for the engine that is the body develops through oxidation a definite amount of energy from a known quantity of food. Since the total energy which the body requires for the performance of its functions is accurately known, the fuel values of all diets should be carefully adjusted to the patient's needs.

No attempt will be made to discuss here the dietetic treatment of the different diseases. For such details the reader is referred to the appropriate chapters. The purpose of this chapter is to furnish simply the information with the aid of which diets may be arranged for any disease.

FOODS

Voit defines a food as a palatable mixture of foodstuffs which is capable of maintaining the body in an equilibrium of substance or capable of bringing it to a desired condition of substance. The ideal food is a palatable mixture of foodstuffs arranged together in such proportion as to

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Suki, T Journ Biol Chem, ii, 251, 1906

See in this connection the fundamental Studies of Wolfgang Ostwald according to whom the poisonous effects of any solution may be expressed mathematically

Fries Pflugers Arch cxx 60 136 (three papers), 1907
Haake, B and Spiro K Hofmeisters Beitr ii, 149, 1902
Limbeck, von Arch f exper Path u Pharmakol xxv, 89, 1888
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——— Kolloid Ztschr ii 108 and 138, 1907
Ostwald, Wolfgang and Dernoschek, A Ibid, vi, 297, 1910
Sollman, Torald Arch f exper Path u Pharmakol, xlvi, 13, 1901

See in connection with this problem

Bechhold, H Kolloide in Biologie und Medizin, 28, Dresden 1912
Goppelsroeder Kolloid Ztschr, iv, 23, 94 191, 236, 312, 1909
Henderson L. J Ergebn d Physiol, viii, 254, 1909
Van Bemmelen J M Die Absorption 44, Dresden, 1910

For an interesting list of such conditions see

Durig Pflugers Arch 1902 1903
Fischer, Martin H Physiology of Alimentation, 182 187, 267 269, New York, 1907
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animal fats are chiefly mixtures of the esters of oleic, stearic and palmitic acid The fat of milk contains besides these, considerable amounts of the lower fatty acids such as butyric, caproic, caprylic and capric acid The triglycerids of linoleic, lauric, myristic, etc, are found in great abundance in the vegetable kingdom

In addition to the neutral fats foods contain various fatlike substances known as lipoids, some of these lipoid substances may have considerable importance in nutrition but as yet we do not know their exact importance Representatives of the lipoids are cholesterin and lecithin

Vitamins—Vitamins are organic substances of unknown chemical constitution they occur in small quantities in many foods, and are of the utmost importance in nutrition

Inorganic Substances—The inorganic substances are water and the salts of sodium, potassium, magnesium, chlorin, sulphur, phosphorus, iron and iodin

Uses of Foods

The chief functions of food are (1) to yield energy, (2) to build tissue (3) to regulate body processes

Uses of Proteins—Proteins are the only foodstuffs capable of supplying the nitrogenous needs of the body while all the organic foodstuffs are capable of furnishing energy Both vegetable and animal proteins are apparently equally serviceable in furnishing the nitrogenous needs As a source of energy, protein, in amounts recommended by Voit and Atwater represents from 16 to 20 per cent of the total metabolism and a lesser amount in the standard recommended by Chittenden

The protein molecule consists of about 50 to 60 per cent of a carbonaceous group or 'carbon moiety' which is split off and oxidized like carbohydrate to carbon dioxid and water In diabetes mellitus part or all of this, depending on the severity of the case will appear in the urine as glucose

The nitrogen of protein taken in excess of the body's needs is rapidly excreted, appearing in urine chiefly in the form of urea There is a nitrogen retention in the body during growth, pregnancy and convalescence from wasting diseases

Adequate and Inadequate Proteins—Some proteins when fed together with sufficient non protein material, vitamins, water and salts, furnish all the nitrogenous compounds necessary for growth and maintenance others under the same conditions fail to support growth or maintenance or both The former group may be called adequate proteins and the latter inadequate proteins The difference in the two groups is in their make-up' of amino-acids While the body can synthesize many of the amino-acids which it uses it apparently cannot synthesize certain ones which are necessary for maintenance and growth

burden the organism with a minimum amount of labor It should be added that the vitamin content of the food must be unimpaired.

Foodstuffs

Practically all of our foods, as ordinarily served, are mixtures of food stuffs A foodstuff is a material capable of being added to the body's substance, or one which when absorbed into the blood-stream will prevent or reduce the wasting of a necessary constituent of the organism (Lusk)

Foodstuffs are classified as follows (1) proteins, (2) carbohydrates, (3) fats (4) vitamins (5) inorganic substances

Proteins—Proteins may be defined as complex organic compounds of high molecular weight made up of carbon, hydrogen, oxygen, nitrogen, sulphur, and sometimes containing phosphorus and iron Protein contains nitrogen in a form available for the physiological needs of the organism, and this differentiates it from other food stuffs Considered from a chemical standpoint proteins consist wholly, or in part, of amino-acids united by their carboxyl and amino groups

Proteins are found in nature in living matter, or associated with it, and always produced by it They comprise gliadin, casein, egg albumin, gluten, edestin, etc

Carbohydrates—Carbohydrates are abundant in the plant kingdom, forming the chief mass of the dry substance of the plant structure In animal tissue they are found in small quantities either in a free condition or in combination with nitrogenous substances The carbohydrates are the chief source of energy to the body and therefore are of great importance in nutrition They contain the elements carbon hydrogen and oxygen, the last two elements are usually in the ratio of 2 1, but not all compounds having this ratio are carbohydrates as (CH_3COOH) acetic acid

It is difficult to give an exact definition of carbohydrates, however chemically they may be defined as aldehyds or ketones of the polyhydric alcohols The carbohydrates are generally divided into three group monosaccharids such as dextrose and levulose, disaccharids such as sucrose, maltose, and lactose, and polysaccharids such as starch, dextrin, and cellulose The ending "ose" is given to the monosaccharids and disaccharids according to the number of carbon atoms contained in the molecule Thus, one speaks of a pentose $C\ H_{11}O_5$, or a hexose $C_6H_1\ O_6$, or a hexobiose $C_1\ H\ O_{11}$

Fats—Fats are distributed widely in both animal and plant kingdoms In the latter they occur chiefly in the seeds, fruits, and in some instances in the roots They occur in all animal tissues in varying quantity

Chemically the neutral fats are the glyceryl esters of fatty acids The

neum, and the tissues about the kidneys These depots constitute a reserve supply of fat to be called upon in time of need The duration of life under the condition of starvation generally depends upon the quantity of fat present in the organism at the start (Lusk) The sources of the body fat are the fat of the food which may be deposited without change, and carbohydrate, which is readily transformed into fat

It has not been definitely proven whether fat can be formed in the human body from protein however the evidence tends strongly to substantiate such a view Fats may be formed from carbohydrates but the exact mechanism of the process is still somewhat obscure It is likewise uncertain whether glycogen can be formed from fat

Uses of Water—Approximately two-thirds of the body consists of water Water forms an integral part of practically all the tissues, and serves as a means of transporting nutrients to and waste products from, the cells Since water is constantly given off from the body through the kidneys skin lungs, and in the feces it is evident that to maintain the composition of the tissues, these losses must be made good Animals die sooner of thirst than of hunger Deprivation of water causes not only a change in the composition of the tissues, but appears to lead to the development of toxic albuminous products

The average daily water requirement is about two liters, of which one-fourth is taken in the form of solid food The demand for water in health varies directly with the losses which in turn vary with the amount of exercise the external temperature and the character of the diet A diet consisting largely of protein increases the desire for water The variations in the demand for water which are occasioned by disease are seen in fevers diabetes mellitus and chronic interstitial nephritis

Deprivation of water increases the destruction of protein in the majority of instances, though to a less extent in fat than in spare persons Pavlov has called attention to the diminution of the gastric and pancreatic secretions which follows a deficient intake of water Limiting the amount of water does not increase the destruction of fat as was formerly believed This fact has special significance in the treatment of obesity

Uses of Salts—Organic life is dependent upon the presence of salts Salts enter into the composition of living matter, and therefore are true foods

The elements concerned in mineral metabolism have a diversity of important functions in the body The skeletal structure of the body, namely bone owes its permanence and rigidity to its composition of the mineral salts furthermore they are essential solid constituents of the soft tissues of the body such as muscles, etc By virtue of their being soluble salts held in solution in the various fluids of the body, they exert their influence in blood-clotting irritability of muscle and nerve and the maintenance of the slight alkalescence of the body fluids at the same

Gelatin is an inadequate protein, as, while it is readily digested and oxidized to carbon dioxid water, and urea and yields energy, it is incapable of maintaining the body in nitrogen equilibrium Gelatin is deficient in tryptophan, tyrosin and cystin Osborne and Mendel working with other deficient proteins have come to the conclusion that the amino-acids, lysin, tryptophan and cystin are necessary as constructive units in growth, and that tryptophan and cystin are necessary for maintenance

Under practical conditions however, we are not dealing with single purified proteins since our common protein foods all contain mixtures of proteins Thus any of the foods will furnish more than one protein. Osborne and Mendel have demonstrated that proteins will supplement each other

Uses of Carbohydrates—Carbohydrates are the chief source of the body s energy, whether expressed in the form of muscular work or in the form of heat The carbohydrate of the food is transformed into glycogen and stored principally in the liver and muscles until needed An excess of carbohydrate over the daily needs leads to more complete filling of the glycogen depots or it is transformed into and stored as fat The body has not however an unlimited tolerance for carbohydrate If too much be taken sugar appears in the urine, producing alimentary glycosuria This is especially true for sugars It has been stated that no amount of starch in the food can cause glycosuria except in diabetics or those predisposed to the disease because of its slow rate of absorption

Another function which carbohydrate serves is to spare protein When neither carbohydrate nor fat is available, as in the late stages of starvation practically all of the energy is derived from protein If protein and carbohydrate alone or protein and fat alone be given to an animal, less protein is destroyed with a liberal supply of carbohydrate than a liberal supply of fat Rubner succeeded in reducing the nitrogen output of a starving man one-half by giving carbohydrate Carbohydrate is therefore called a sparer of protein, and it is evident that carbohydrate is a better sparer of protein than fat But if both carbohydrate and fat be given, in addition to protein, they appear to be dynamically equivalent calory for calory Landergren found that a diet furnishing one-half of its calories as fat and one-half as carbohydrate protects protein as completely as a diet composed entirely of carbohydrate

While carbohydrate cannot replace the protein required for the growth and repair of the cells of the body, it is probably necessary for the formation of the perfect protein molecule

Uses of Fat—Fat constitutes an important source of energy, and, like carbohydrate, is a sparer of protein The fat of the food, when not needed immediately for oxidation, is deposited in the tissues of the body The principal fat depots are the subcutaneous tissues, the liver, the perito-

grow and usually develop the eye disease The occurrence of the eye disease has also been noted among children suffering from vitamin (A) deficiency Block reports of the Danish children whose xerophthalmia yielded readily to diets rich in vitamin (A) McCollum, Simmonds and Parsons have attributed "night blindness" an eye trouble in northern regions to use of diets poor in vitamin (A) The lack of vitamin (A) may cause abnormalities and weaknesses other than the eye Osborne and Mendel refer to diarrhea and diminished appetite, and McCollum and Davis and Drummond to lung weakness

Distribution of Vitamin (A) —It is quite widely distributed through out nature occurring in many of the animal fats such as butter fat and cod liver oil, but is generally lacking in all vegetable oils It is present in most of the leafy foods and in many roots such as carrots and sweet potatoes

Physical and Chemical Properties of Vitamin (A) —It is usually associated with fats and is soluble in the ordinary fat solvents It is quite readily destroyed by oxidation such as aeration at high temperature or ozone It is not very rapidly destroyed at temperatures below 100 C and apparently withstands such treatment as cooking, canning and drying

Vitamin (B) —To Eijkman and Hopkins we must attribute the credit of calling attention to this unknown substance which Funk christened *vitamin* Beriberi a disease of the Orient where polished rice and fish are the principal foods has long been known Eijkman in 1897 was able to produce a similar condition in pigeons and found that by adding the rice polishings to the diet the symptoms were relieved The growth promoting substances demonstrated by Hopkins in milk and called by McCollum water soluble (B) are probably identical with the antineuritic substance which Funk called vitamin however there is some difference of opinion as to whether vitamin (B) is an entity

Effect of Lack of Vitamin (B) —In diets lacking in vitamin (B) young animals cease to grow become weak and usually polyneuritic In man it may lead to beriberi Mendel and Osborne and Karr have demon strated the influence of vitamin (B) upon the appetite

Occurrence of Vitamin (B) —In plants it appears relatively abun dantly in leaves roots tubers seeds and fruits, and in animals in the glandular organs eggs and milk

Physical and Chemical Properties of Vitamin (B) —It is readily soluble in water and dilute alcohol It is more stable in acid than alkaline solutions Chick and Hume have found that it is little destroyed by two hours heating at 100 C, about one-half destroyed in forty minutes at 113° C and up to nine-tenths destroyed in two hours at 118° to 124 C From these results little destruction should occur in ordinary cooking but commercial canning and sterilizing may cause considerable loss In cook

time furnishing acidity or alkalinity to the digestive juices They also influence the solvent power and osmotic pressure of the blood and tissue fluids

A man under average conditions excretes from 20 to 30 grams of mineral salts per day

The Vitamins

Studies in nutrition in recent years have firmly established that the food factors known as vitamins are indispensable for the welfare of the animal organism It is only within the last ten or fifteen years that we have realized that chemical analyses of foods for proteins, carbohydrates and minerals are insufficient to reveal their biologic value Formerly a food was considered sufficient for nutritive requirements of the body if it fulfilled certain established standards as to total digestibility, available energy and proteins To-day, in addition to the above requirement, we recognize the need of certain essential substances—the vitamins

Hopkins was the first to demonstrate clearly that normal nutrition requires other food substances than proteins, carbohydrates, fats and minerals The name vitamine was given to these substances by Casimer Funk in connection with his work on beriberi McCollum and Kennedy suggested that we call them fat soluble (A), water soluble (B), to which was soon added water soluble (C) Drummond has simplified the terminology by proposing that we drop the final *e* and retain vitamin as a group name and use letters for distinguishing the various known members until chemical names are justified Hence according to Drummond they shall be called vitamin (A), (B), (C) (D), etc. This later terminology has been quite generally accepted and will be used in the following discussion

Our knowledge of vitamins is still in the "making" and our present concept may be wholly changed in the coming years At present we know *of three vitamins with quite strong evidence of a fourth* The chemical constitution of all is still unsolved

Vitamin (A)—Hopkins in 1906, found that young mice failed to grow upon a mixture of purified proteins, carbohydrates, fats and salts, while the addition of milk or the alcoholic extract of milk rendered such a diet adequate for normal nutrition and growth McCollum and Davis, and Osborne and Mendel independently discovered that young rats grew or failed to grow depending whether the diet contained butter or lard This gave evidence of some fat soluble substance in butter fat which promoted growth Later Osborne and Mendel found that rats suffering from lack of vitamin (A) developed a peculiar eye disease called "xerophthalmia"

Effect of Lack of Vitamin (A)—Young animals at least cease to

In order to include vitamins in our diets, it becomes necessary to know how to choose such a diet. Certain approximations of the vitamin content of foods have been made and may be used as a limited guide in selecting vitamin diets. The following table has been copied from *The Vitamin Manual* and acknowledgment is hereby given.[1]

VITAMIN CONTENT OF FOODS*

Class of Foodstuff	Vitamin (A)	Vitamin (B)	Vitamin (C)
Fats and oils			
Butter	+++	0	
Cream	++	0	
Cod liver oil	+++	0	
Mutton and beef fat or suet	++		
Lard	0		
Olive oil	0		
Cottonseed oil	0		
Coconut oil	0		
Cocoa butter	0		
Linseed oil	0		
Fish oil, whale oil, herring oil, etc.	++		
Hardened fats (hydrogenated) of animal or vegetable origin	0		
Margarin from animal fat	In proportion to animal fat used		
Margarin from vegetable fat or lard	0		
Nut butters	+		
Meat, fish, etc.			
Lean meat (beef, mutton, etc.)	+	+	+
Liver	++	++	+
Kidneys	++	+	
Heart	++	+	
Brain	+	++	
Sweetbreads	+	++	
Fish, white	0	Very slight if any	
Fish, fat (salmon, herring, etc.)	++	Very slight if any	
Fish roe	+	++	
Tinned meats	?	Very slight	0

+++ indicates abundant, ++ relatively large, + present in small amount, 0 absent.

[1] Eddy, Walter H., The Vitamin Manual, published by Williams and Wilkins.

ing it may be very nearly all lost by extraction if the cooking water is rejected

Vitamin (C) —Scurvy has long been attributed to a faulty diet Holst and Frohlich found that guinea pigs readily developed scurvylike symptoms when fed on a cereal or bread diet These workers found that the introduction of fresh carrots or cabbage would readily cure the diseased condition They concluded that scurvy is caused by a lack of a chemical substance from the scorbutic diets, and further demonstrated that it was easily destroyed by cooking or drying That scurvy is a deficiency of vitamin (C) has been affirmed by Hess, Cohen and Mendel and others

Effect of Lack of Vitamin (C) —The lack of vitamin (C) causes the development of scurvy both in young and adult The disease is characterized by swollen and bleeding gums, loosening of the teeth, and characteristic lesions of the mucous membranes

Distribution of Vitamin (C) —Among the vegetable foods, fruits and succulent vegetables, such as oranges, lemons, tomatoes and fresh cabbage, are the best sources In the animal products it is present in milk and small quantities in meat

Physical and Chemical Properties of Vitamin (C) —It is readily water soluble, and more stable in acid than alkaline solutions It is quite readily destroyed by heat oxidation and drying From studies made on its stability it is found that less of its potency is lost in heating at a high temperature for a short time than the reverse This is important in the matter of dried milk Hart, Steenbock and Smith have found that dried milk made by the drum process retains considerable antiscorbutic value, while that made by the spray process is of much less potency

Vitamin (D) —Recently strong evidence is being furnished that we have a fourth member of the interesting vitamin family vitamin (D), which is intimately connected with the calcification of bone Hess in his studies upon infantile rickets has demonstrated that cod liver oil is almost a specific for rickets McCollum, Simmonds Shipley and Park present very substantial evidence of an antirachitic vitamin present in cod liver oil which is distinct from vitamin (A) So far this vitamin seems to be limited to the fish liver oils such as cod liver oil

Selection of Vitamin Diets —There is no reason to suppose that the vitamin needs of the body cannot be supplied by use of our widespread natural foods Many widely advertised products have appeared on the market, claiming special virtue in their vitamin content Bailey at the Connecticut Agricultural Experiment Station has biologically analyzed a number of these commercial vitamin compounds, using as a standard dried brewer's yeast When analyzed on this basis, approximately 50 per cent of the advertised compounds showed inferior vitamin content A few showed about an equal potency and only two or three of the products studied showed a greater potency than yeast

VITAMIN CONTENT OF FOODS* (*continued*)

Class of Foodstuff	Vitamin (A)	Vitamin (B)	Vitamin (C)
Vegetables and fruits—Cont			
Lime juice fresh			++
Lime juice preserved			Very slight
Orange juice fresh			+++
Raspberries			++
Apples			+
Bananas	+	+	Very slight
Tomatoes canned			++
Nuts	+	++	
Miscellaneous			
Yeast dried	?	+++	
Yeast extract and autolyzed	?	+++	0
Meat extract	0	0	0
Malt extract		+ in some specimens	
Beer		0	0
Honey		+	
Meats			
Beef heart	+	+	?
Brains	++	+++	+ ?
Codfish	+	+	?
Codtestes	+		
Fish roe	+	++	?
Herring	++	++	?
Horse meat	+	+	
Kidney	++	++	
Lean muscle	0	0	+ ?
Liver	+	+	+ ?
Pancreas	0	+++	
Pig heart	+	+	?
Placenta		+	
Thymus sweetbreads	0	0	0
Vegetables			
Beet root	+	+	+
Beet root juice	?	Little	+++
Cabbage dried	+++	+++	+
Cabbage fresh	+++	+++	++++
Carrots	+++	+++	++
Cauliflower	++	+++	++
Celery	?	+++	?
Chard	+++	++	?
Dasheens	+	++	?
Lettuce	++	++	++++
Mangels	++	++	?
Onions	?	+++	+++
Parsnips	++	+++	
Peas fresh	+	++	+++

+++ indicates abundant; ++ relatively large; + present in small amount; 0 absent

VITAMIN CONTENT OF FOODS* (*continued*)

Class of Foodstuffs	Vitamin (A)	Vitamin (B)	Vitamin (C)
Milk, cheese, etc			
Milk, cow's, whole, raw	++	+	+
Milk, cow's, skim	0	+	+
Milk, cow's, dried whole	Less than ++		Less than +
Milk, cow's, boiled whole	?		Less than +
Milk, cow's, condensed sweetened	+	+	
Cheese, whole milk	+		Less than +
Cheese, skim milk	0		
Eggs, fresh	++	+++	0?
Eggs, dried	++	+++	0?
Cereals, pulses, etc			
Wheat, maize, rice (whole germ)	+	+	0
Wheat, maize, rice germ	++	+++	0
Wheat, maize, rice bran	0	++	0
White wheat flour, pure corn flour, polished rice, etc	0	0	0
Custard powders, egg substitute, prepared from cereal products	0	0	0
Linseed, millet	++	++	0
Dried peas, lentils, etc		++	
Pea flour, kilned		0	0
Soy beans, haricot beans	+	++	0
Germinated pulses or cereals	+	++	++
Vegetables and fruits			
Cabbage, fresh, raw	++	+	+++
Cabbage, fresh, cooked		+	+
Cabbage, dried	+	+	Very slight
Cabbage, canned			Very slight
Swedes, raw, expressed juice			+++
Lettuce	++	+	
Spinach, dried	++	+	
Carrots, fresh, raw	+	+	+
Carrots, dried	Very slight		Less than +
Beetroot, raw, expressed juice	+	+	
Potatoes, raw			+
Potatoes, cooked			++
Beans, fresh, scarlet runners, raw			
Lemon juice, fresh			+++
Lemon juice, preserved			

+++ indicates abundant, ++ relatively large, + present in small amount, 0 absent

Vitamin Content of Foods* (*continued*)

Foodstuff	Vitamin (A)	Vitamin (B)	Vitamin (C)
Oils and fats			
Almond oil	0	0	
Beef fat	+	0	0
Butter	++++	0	0
Coconut oil	0	0	0
Cod liver oil	++++	0	0
Corn oil	0	0	0
Cotton seed oil	0 ?	0	0
Egg yolk fat	++++	0	0
Fish oils	++	0	0
Lard	0 ?	0	0
Oleo animal	+	0	0
Oleo vegetable	0	0	0
Olive oil	0	0	0
Pork fat	0 ?	0	
Tallow	0	0	0
Vegetable oils	0 ?	0	0
Nuts			
Almond	+	+++	
Brazil nut		+++	
Chestnut		+++	
Coconut	++	+++	
English walnut		+++	
Filbert		+++	
Hickory	+	+	+
Pine	+	+	+
Dairy products			
Butter	++++	0	0
Cheese	++	+	?
Condensed milk	++	+	0
Cream	+++	+	?
Eggs	++++	++	0
Milk powder skim	+	+++	+ ?
Milk powder whole	+++	+++	+ ?
Milk whole	+++	+++	++
Whey	+	+++	+
Miscellaneous			
Alfalfa	+++	+++	?
Blood		Varies with source	
Clover	+++	++++	?
Honey		++	0
Malt extract	0	0	0
Nectar	0	0	0
Timothy	++	+++	
Yeast, brewer's	0	++++	0
Yeast cakes	0	++	0
Yeast extract	0	+++	0

+++ indicates abundant ++ relatively large + present in small amount 0 absent

VITAMIN CONTENT OF FOODS* (*continued*)

Foodstuff	Vitamin (A)	Vitamin (B)	Vitamin (C)
Vegetables—Cont			
Potatoes	0	+++	++
Potatoes sweet	+++	++	?
Rutabaga		+++	
Spinach	+++	+++	+++
Cereals			
Barley	+	+++	?
Bread white		+ ?	
Bread whole meal	+	+++	?
Maize	+ In yellow 0 In white	+++	?
Oats	+	+++	0
Rice polished	0	0	0
Rice whole grain	+	+++	0
Rye	+	+++	0
Corn embryo		+++	
Corn kaffir		+++	
Corn (*see* Maize)			
Corn pollen		++	
Malt extract	0	0	0
Wheat bran	0	+	0
Wheat embryo	++	+++	0
Wheat endosperm	0	0	0
Wheat kernel	+	+++	0
Other seeds			
Beans kidney		+++	
Beans navy		+++	0
Beans soy	+	+++	0
Cotton seed	++	+++	
Flaxseed	++	+++	
Hemp seed	++	+++	
Millet seed	++	+++	
Peanuts	+	++	
Peas dry	+ ?	++	0
Sunflower seeds	+		
Fruits			
Apples		++	++
Bananas	?	+	++
Grapefruit		+++	+++
Grape juice		+	+
Grapes	0	+	+
Lemons		+++	++++
Limes		++	++
Oranges		+++	++++
Pears		++	++
Raisins		+	+
Tomatoes	++	+++	++++

+++ indicates abundant ++ relatively large + present in small amount 0 absent

VITAMIN CONTENT OF FOODS* (*continued*)

Foodstuff	Vitamin (A)	Vitamin (B)	Vitamin (C)
Oils and fats			
Almond oil	0	0	
Beef fat	+	0	0
Butter	++++	0	0
Coconut oil	0	0	0
Cod liver oil	++++	0	0
Corn oil	0	0	0
Cotton seed oil	0 ?	0	0
Egg yolk fat	++++	0	0
Fish oils	++	0	0
Lard	0 ?	0	0
Oleo animal	+	0	0
Oleo vegetable	0	0	0
Olive oil	0	0	0
Pork fat	0 ?	0	
Tallow	0	0	0
Vegetable oils	0 ?	0	0
Nuts			
Almond	+	+++	
Brazil nut		+++	
Chestnut		+++	
Coconut	++	+++	
English walnut		+++	
Filbert		+++	
Hickory	+	+	+
Pine	+	+	+
Dairy products			
Butter	++++	0	0
Cheese	++	+	?
Condensed milk	++	+	0
Cream	+++	+	?
Eggs	++++	++	0
Milk powder skim	+	+++	+ ?
Milk powder whole	+++	+++	+ ?
Milk whole	+++	+++	++
Whey	+	+++	+
Miscellaneous			
Alfalfa	+++	+++	?
Blood		Varies with source	
Clover	+++	++++	?
Honey		++	0
Malt extract	0	0	0
Nectar	0	0	0
Timothy	++	+++	
Yeast, brewer's	0	++++	0
Yeast cakes	0	++	0
Yeast extract	0	+++	0

+++ indicates abundant ++ relatively large + present in small amount 0 absent

Condiments.—Under the general term, "accessory articles of diet," are classed the condiments, flavors, and stimulants. These substances are added to our diets to increase their attractiveness and palatability, although they may impart a certain amount of energy by their oxidation. Some of these substances, due to their increasing palatability, exert a so-called psychical stimulation which facilitates gastric secretion and thus materially aids in gastric digestion.

Gauthier has divided condiments into the following classes: (1) aromatic, comprising vanilla, anise, cinnamon, nutmeg, and other essential oils; (2) peppers; (3) the alliaceous condiments—garlic, mustard, etc.; (4) acid condiments—vinegar, citron, pickles, etc.; (5) the salty condiments, such as table salt; (6) the sugar condiment. Under the head of stimulants are included alcohol, tea, coffee, cocoa, chocolate, and meat extracts.

Alcohol.—The exact value of alcohol as a food is somewhat uncertain. Experiments made on man, however, clearly show that alcohol is burned up in the body. Its potential energy is transformed into kinetic energy, and therefore alcohol is considered as having food value. While it acts as a food sparer, it may not be a desirable food. Prior to its oxidation in the body, alcohol may produce deleterious effects of various kinds, which counterbalance the gain from its oxidation.

Tea and Coffee.—The stimulating effect of tea and coffee is due to the presence of caffein. This alkaloid has a diuretic action on the kidney and raises blood pressure. Muscular energy is augmented and the sense of fatigue is dissipated by the use of these stimulants.

Cocoa.—Chocolate made from cocoa by the addition of sugar and flavoring agents acts as a stimulant through its content of theobromin. It also contains fats, carbohydrates and protein.

Meat Extracts.—In themselves these extracts have very little food value. Their value lies in their content of nitrogenous extractives, many of which are stimulants. They also call forth a copious secretion of gastric juice and for this reason have been called secretogogues.

ACID-FORMING AND BASE-FORMING FOODS

The reaction of normal human blood is slightly alkaline, but this is so slight that blood and protoplasm may be spoken of as neutral.

The processes of metabolism cause a continual production of acid (carbonic, phosphoric, and sulphuric) which must be disposed of in order to maintain neutrality.

The factors that are concerned in the maintenance of neutrality are (1) carbonates, (2) phosphates, (3) ammonia, (4) proteins.

Henderson has worked out the various relationships of the different factors in the maintenance of neutrality under normal conditions. The

hydrogen ion concentration depends upon the ratio of $\frac{H_2CO_3}{NaHCO_3}$ The mechanism of the maintenance of this ratio is too involved for detailed discussion here, and the reader is referred to other sources

The normal acid production in man on mixed diets is taken care of, in part at least, by the formation and excretion of acid phosphates An increased acidity of the urine usually means an increased ratio of primary phosphates to secondary phosphates but without any necessary increase of fixed alkali leaving the body In the neutralization of sulphuric acid by phosphates each molecule of sulphuric acid converts two molecules of secondary into primary phosphate This surplus of acid phosphate must be excreted to maintain the normal equilibrium The neutralization of sulphuric acid, formed in the metabolism of proteins by potassium or sodium carbonate of the blood may lead to a depletion of fixed alkali in the blood

Formerly it was believed that ammonia was used for neutralization of acid by the liver and tissues Recently however Nash and Benedict have demonstrated that ammonia does not exist in the blood except in traces, and that the kidney is the seat of ammonia formation Under these circumstances acids must be transported in the body in combination with fixed bases or proteins Thus there may occur a loss of fixed alkali from the body when there is a more rapid introduction of acid radicals into the blood stream than the normal kidney can eliminate or can make ammonia to combine with them while eliminating Thus when there is an abundance of strong acid to be neutralized unless made good by the base forming elements of the food there probably results loss of fixed alkali with a lowering of the alkali reserve of the blood. Hence there is a relationship among the ash constituents of the food in acid forming and base forming elements in the maintenance of neutrality of the body

While a continuous excess of acid forming elements in the diet is probably not harmful, the decreased uric acid solvent power of acid urines is well known

Blatherwick has studied a considerable number of the foods, and found that foods with a preponderance of base forming elements tended to decrease the acidity of the urine and to increase its solvent power for uric acid while a preponderance of acid forming elements tended to form a more acid urine with a decreased uric acid solvent power and a tendency toward a depletion of the alkali reserve

The following foods have been studied by Sherman and Gettler [3]

Van Slyke and Coworkers Journal of Biological Chemistry 1917 xxx 89 347 401 1917 xxxi 4 495 1918 xxxiii 71 1919 xxxviii 167 1920 xli 567 1921 xlviii 153

Sherman and Gettler Journal of Biological Chemistry 1912 xi 5 3

Ash Analyses of Sherman and Gettler Excess of Acid-forming or Base-forming Elements

(Excess Acid or Base in Terms of Normal Solutions)

Articles of Food	Per 100 Grams		Per 100 Calories	
	Acid c.c.	Base c.c.	Acid c.c.	Base c.c.
Almonds		12.38		1.86
Apples		3.76		5.98
Asparagus		0.81		3.65
Bananas		5.56		5.62
Beans dried		23.87		6.92
Beans lima dried		41.65		12.08
Beets		10.86		23.57
Cabbage		4.34		13.76
Carrots		10.82		23.91
Cauliflower		5.33		17.48
Celery		7.78		42.17
Cherry juice		4.40		
Chestnuts		7.42		3.19
Corn sweet dried	5.95		1.77	
Crackers	7.81		1.95	
Currant dried		5.97		1.85
Eel	9.89			
Eggs	11.10		7.[illegible]	
Egg white	5.24		9.52	
Egg yolk	26.69		7.08	
Fish haddock	16.07			
Fish pike	11.81			
Lemons		5.45		12.32
Lettuce		7.37		38.69
Meat beef lean	13.91		12.10	
Meat chicken	17.01			
Meat frog	10.36			
Meat pork lean	11.87			
Meat rabbit	14.80			
Meat veal	13.52			
Meat venison	15.83			
Milk cow's		2.37		3.44
Muskmelon		7.47		18.82
Oatmeal	12.93		3.23	
Oranges		5.61		10.94
Peaches		5.04		12.20
Peanuts	3.9		0.70	
Peas dried		7.07		1.98
Potatoes		7.19		8.63
Prunes		24.40		8.05
Radishes		2.87		9.79
Raisins		23.68		6.87
Raspberry juice		4.91		
Rice	8.1		3.35	
Turnips		2.68		6.86
Wheat entire	9.66		3.25	
Wheat flour	11.61		2.70	

Total Food Requirement

The body derives the energy required for the performance of its functions from the food the potential energy of the food being transformed into heat and work Without some knowledge of the food requirements in health, it will be found difficult to arrange rational dietaries for patients In health the appetite constitutes the chief guide to our needs and is in the main reliable That it is not always so is evidenced by the various disorders from overindulgence or underindulgence in food

Two methods have been employed to determine the daily food requirement of man the empiric and the experimental The empiric method consists in studying the food habits of a large number of people in various occupations and taking the average quantities of food, and foodstuffs, consumed by each class The experimental method consists essentially in measuring in terms of heat, the amount of energy produced by the body under different conditions as when at work at rest, and on different diets Many important facts have been obtained from studies of metabolism carried out upon the lower animals

Our present knowledge concerning metabolism in man has been derived from both the empiric and experimental methods The results of these studies have furnished us with what are known as standard requirements It should be pointed out however that these standards are not absolute, they are simply guides, which may and should, be varied according to the requirements of different individuals

The total food requirement is generally expressed in calories or heat units The term calory unless qualified may mean either the amount of heat necessary to raise 1 gram of water from 0° to 1° C or 1 000 grams of water from 0° to 1° C They are designated respectively as small and large calories Usually the distinction is made by using an initial capital for the large calory thus Calory means large calory The term 'calory,' as ordinarily employed in medical literature, should be interpreted as large calory

The body follows the general law of the conservation of energy, that is the energy yielded by the food which is actually absorbed and oxidized and which is manifested as heat or heat and mechanical work corresponds with the potential energy of the different foodstuffs consumed Therefore it is possible to calculate the fuel value to the body of the different foodstuffs Rubner's figures shown below are generally employed for the purpose

1 gram of protein furnishes	4 1 calories
1 gram of fat furnishes	9 3
1 gram of carbohydrate furnishes	4 1 "
1 gram of alcohol furnishes	7 0 "

The total energy requirement may be expressed as calories per kilogram per day or calories per square meter of body surface per hour. The latter method is the more accurate, and the chart recently published by Du Bois and Du Bois makes the method practicable for bedside work (see Chart).

The total energy requirement of an adult at *absolute rest* (that is, without voluntary movement of any kind) and twelve hours or so after food is 22 to 26 calories per kilogram per day, or 1,540 to 1,820 calories for a man weighing 70 kilograms (154 lbs.). The total energy require-

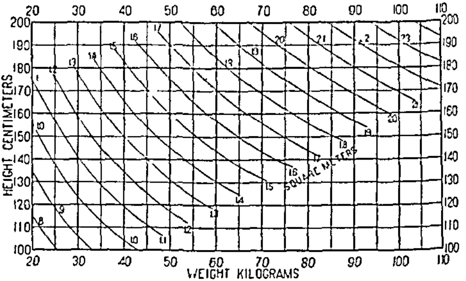

FIG. 1.—CHART FOR DETERMINING SURFACE AREA OF MAN IN SQUARE METERS FROM WEIGHT IN KILOGRAMS AND HEIGHT IN CENTIMETERS. The point of intersection of ordinate and abscissa for any individual is found and the surface area read off on the curved lines. For example, if a man is 150 centimeters in height and weighs 60 kilograms his approximate surface area will be 1.55 square meters. (After Du Bois and Du Bois.)

ment by surface area is 39.7 calories per square meter per hour. Patients confined to bed are never at absolute rest, however, within the meaning of the term, except during sleep or when comatose and the energy value of their food, except under special conditions and for brief periods, should not be permitted to fall below this minimum.

A number of circumstances may modify the demand for energy. Among the more important of these are the age, size of the individual, amount of muscular work, and disturbances of metabolism brought about by various diseases.

Age.—The rate of metabolism varies with the age of the individual. It is greatest in infancy and childhood and lowest in old age. As will

be seen on the chart (Chart 2) metabolism, which is low at birth, rises rapidly during the first year and reaches its maximum somewhere between the first and sixth years (this period has not been thoroughly investigated) After the sixth year it falls rapidly until the age of twenty, and thereafter very slowly There is no difference between the sexes in infancy After the sixth year girls and women have a distinctly lower metabolism Du Bois found the heat production of boys, 12 to 13 years old, to be 25 per cent above the adult level A surplus over the actual demand of the child should always be given to allow for growth

Heubner states that the energy requirement of a child in the first three months of life is 100 Calories per kilogram of body weight per day,

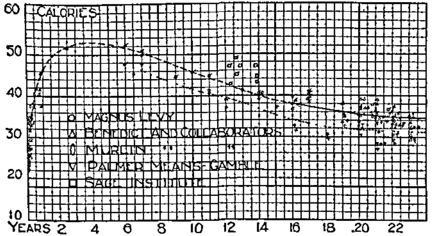

FIG 9 —CHART SHOWING VARIATION OF BASAL METABOLISM WITH AGE Calories per hour per square meter of body surface Meeh formula Dash line shows average for males dotted line for females (After Du Bois)

in the second three months 90 Calories thereafter, 80 Calories and less per kilogram The energy supply should not be allowed to fall below 70 Calories per kilogram

Size—In general persons of large frame and build require more food than those who are small The increase however corresponds to unit of surface area rather than to weight For this reason persons who are fat require relatively less food than those who are thin though a fat person expends more energy in the performance of muscular work because of the greater effort required to move his body

Muscular Work—The performance of muscular work is accompanied by an increase in metabolism and a greater supply of food is demanded The increase is chiefly at the expense of fat and carbohydrate though when they are not available protein may be consumed Many investiga

tions have shown the relation of muscular work to metabolism. The results can be best illustrated by the following table, arranged by Atwater:

Food Consumption of Persons in Different Circumstances and Proposed Dietary Standards*

(Quantities per man per day)

Occupations	Actually Eaten			Digestible			Fuel Value in Calories
	Grams Protein	Grams Fat	Grams Carbohydrates	Grams Protein	Grams Fat	Grams Carbohydrates	
Persons with Active Work							
Rowing clubs in New England	1[illegible]5	177	440	143	168	42[illegible]	3,955
Bicyclists in New York	186	186	651	171	177	631	5,005
Football teams in Connecticut and California	226	354	634	208	336	615	6,590
Prussian machinists	*139*	*113*	*677*	*128*	*107*	*657*	*4,2[illegible]0*
Swedish mechanics	189	110	714	174	104	693	4,590
Persons with Ordinary Work							
Farmers' families in eastern United States	97	130	467	89	124	453	3,415
Mechanics' families in United States	103	150	402	95	143	390	3,355
Laborers' families in large cities of United States	101	116	344	93	110	334	2,810
Laborers' families in United States (more comfortable circumstances)	120	147	534	119	140	518	3,925
Russian peasants	129	33	580	110	31	571	3,165
Swedish mechanics	134	79	523	123	75	507	3,330
Professional Men							
Lawyers, teachers, etc., in United States	104	125	423	96	119	410	3,290
College clubs in United States	107	148	459	98	141	445	3,580
German physicians	131	95	327	121	90	317	2,680
Japanese professor	*123*	*21*	*416*	113	19	403	*2,345*
Men with Little or No Exercise							
Men (American) in respiration calorimeter	112	80	305	103	76	296	2,380
Men (German) in respiration apparatus	127	80	302	117	76	293	2,430
Persons in Destitute Circumstances							
Poor families in New York City	93	95	407	86	90	395	2,845
Laborers' families in Pittsburg, Pa.	80	95	308	74	90	299	2,400
German laborer's family	52	32	287	48	30	278	1,640
Italian mechanics	76	38	396	70	36	384	2,295

* Fat and carbohydrates in sufficient amounts to furnish, together with the protein, the indicated amount of energy.

FOOD CONSUMPTION OF PERSONS IN DIFFERENT CIRCUMSTANCES AND PROPOSED DIETARY STANDARDS (*Continued*)

Occupation	Actually Eaten			Digestible			Fuel Value
	Grams Protein	Grams Fat	Grams Carbohydrates	Grams Protein	Grams Fat	Grams Carbohydrates	Calories
Miscellaneous							
Negro families in Alabama and Virginia	86	145	440	79	138	497	3 395
Italian families in Chicago	103	111	331	95	105	379	2 965
French Canadians in Chicago	118	158	345	109	150	335	3 [illegible]60
Bohemian families in Chicago	115	101	60	106	96	349	2 800
Inhabitants Java village Columbian Exposition 1893	66	19	[illegible]54	61	18	[illegible]46	1 450
Russian Jews in Chicago	137	103	418	1[illegible]6	98	405	3 135
Mexican families in New Mexico	94	71	613	80	67	595	3 460
Chinese dentist in California	115	113	[illegible]89	106	107	2[illegible]0	2 6[illegible]0
Chinese laundryman in California	135	76	566	124	72	549	3 480
Chinese farm laborer in California	144	95	640	13[illegible]	90	6[illegible]1	3 980
United States Army ration peace	1[illegible]0	161	454	110	153	440	3 730
German army ration peace	114	39	480	105	37	466	[illegible] 725
Dietary Standards							
Man at hard work (Voit)	145	100	450	133	95	437	3 2[illegible]0
Man at moderate work (Voit)	118	56	500	109	53	485	[illegible] 965
Man with very hard muscular work (Atwater)	1[illegible]	(*a*)	(*a*)	161	(*a*)	(*a*)	5 500
Man with hard muscular work (Atwater)	1[illegible]0	(*a*)	(*a*)	138	(*a*)	(*a*)	4 150
Man with moderately active muscular work (Atwater)	1[illegible]	(*a*)	(*a*)	115	(*a*)	(*a*)	3 400
Man with light to moderate muscular work (Atwater)	112	(*a*)	(*a*)	103	(*a*)	(*a*)	3 050
Man at sedentary or woman with moderately active work (*Atwater*)	100	(*a*)	(*a*)	92	(*a*)	(*a*)	[illegible] 700
Woman at light to moderate muscular work or man without muscular exercise (Atwater)	90	(*a*)	(*a*)	8[illegible]	(*a*)	(*a*)	[illegible] 450

The energy requirement of adults reduced to calories per kilogram of body weight may be summarized in the following table (von Noorden). In general a man at nearly complete rest requires on the average one calorie per kilogram per hour.

Calories Per Kilogram Per Day

Absolute rest	24-30
Ordinary rest in bed	30-34
Out of bed without work	34-40
Moderate work	40-45
Hard work	45-60

Protein, Fat, and Carbohydrate Ratios

The relative proportions of protein, fat, and carbohydrate which should enter into the diet must be considered, as well as the total food requirement.

Protein Requirement.—The daily protein requirement is an important question in nutrition and has been the subject of much discussion. The optimum protein ration has not yet been determined. It probably varies with different individuals and under different conditions, such as external temperature, amount of work done, etc.

It has been assumed that a healthy man under normal conditions would consume daily the amount of protein which he has found by experience to be suited to his needs. The almost universal support which has been accorded to Voit's recommendation, until recently, is essentially a recognition of this assumption. After studying the food habits of a large number of people Voit placed the daily protein requirement of a man at light work at 118 grams. Atwater employing the same method, found the requirement to be 125 grams a day. But within the last fifteen years or so the correctness of the Voit and Atwater standards has been called into question, largely on the basis of experimental as contrasted with statistical studies. Probably the most important of these investigations has been carried out by Chittenden.[4] He believes "that the Voit and Atwater standards call for amounts of protein food far beyond the requirements of the body . . . provided the total calorific value of the food is sufficient . . . that the need for protein food may be fully met by a daily metabolism equal to an exchange of 0.12 grams of it per kilogram of body weight." For a man of 70 kilograms (154 pounds), this represents 60 grams of protein a day, which is about one-half the Voit and less than half the Atwater standards. Chittenden's investigations were carried out on professional men, students, and soldiers. The case of Professor Chittenden himself, suffering as he had for years from "rheumatism," "bilious attacks," and sick headaches, falls rather into the category of disease with possible disorders of digestion or metabolism, so that an excess of protein over his minimal needs acted injuriously.

It will be assumed in the discussion of the daily protein requirement that fat and carbohydrate are supplied in sufficient amounts.

More recently Chittenden has employed the statistical method on 108 healthy persons selected at random and he states that as a group they represented the average type of vigorous manhood common to most university centers They metabolized on an average 0 1J gram of nitrogen per kilogram of body weight as contrasted with the 0 22 gram of the Voit standard There is, therefore close correspondence between Chittenden's experimental and statistical results The statistical observations especially raise the question whether there may not be many per ons whose daily protein requirement is entirely satisfied by appreciably less protein food than is called for by the Voit and Atwater standards

Chittenden s views have met with vigorous opposition It has been pointed out that the most progre sive races of mankind consume protein in quantities approximating the Voit and Atwater standards Benedict cites the poor whites and negroes of the South as examples of the deleterious effect of the low protein diet Niceforo calls attention to the sociological status of the laborers of southern Italy, and thinks it due to the small amount of protein in their diet McCay has shown that the Bengalis who are inferior in physical development to the Anglo-Indians and Eurasians metabolize only about 7 grams of protein a day, or 0 11 gram nitrogen per kilogram of body weight But it cannot yet be assumed that the relation of cause and effect in these cases has been established

Experiments upon the lower animals indicate that the injurious effects of a low protein diet may not manifest themselves for a year or more, and while it does not necessarily follow that similar injurious effects may be caused in man yet the experiments suggest the need for caution in accepting Chittenden s conclusions According to Lusk, there appears to be no strongly substantiated argument why that portion of mankind living in a cool climate should not follow the general custom of taking a medium amount of protein in moderate accordance with the dictates of their appetites

Only a limited number of investigations into the protein requirement in disease have been made and an attempt to state the requirement for different diseases would not be justified Therefore until the daily protein requirement both in health and disease is more definitely determined the wi est course for physicians and others, who have control of dietaries appears to be to follow the older standards or at least to permit persons to gratify their desire for protein food

Variations in the Protein Requirement —The demand for protein varies within much narrower limits than the demands for fat and carbohydrate An excess of protein is needed during the period of growth and according to Lusk, during training to provide for the accompanying hypertrophy of the mu cles

The demand appears to vary also with different persons of the ame sociological status It is a matter of common observation that some per

sons eat more meat than others, and claim that their efficiency is impaired if their usual supply is diminished. Old people, as a rule, take less protein than those in active middle life.

Though protein is not concerned directly in the production of energy for muscular work, provided the fat-carbohydrate supply is sufficient, a greater amount of protein is allowed by both the Voit and Atwater standards for occupations entailing physical exertion. No entirely satisfactory explanation of the increased demand has been offered. Voit assumed that muscles engaged in active work must have a free supply of protein quickly available. Magnus Levy thinks that the increased consumption of protein is not the result of purposeful selection, but is incidental to the increase in the total food.

The inclination to diminish the amount of protein in hot weather and hot climates is general and finds its explanation in the high *specific dynamic action* of protein, that is, the high proportion of potential energy which is liberated as free heat and which does not take part in the vital activities of the cells.

Our knowledge of the protein requirement in pathological states is very incomplete. Large amounts of protein are often taken in diabetes mellitus and exophthalmic goiter. The belief is current that an excess of protein is required during convalescence from the acute infective diseases because of the febrile destruction of protein which occurs, but there is reason to question whether an excess is required, if, during the course of these diseases, adequate supplies of carbohydrate and fat are furnished.

Injurious Effects of an Excess of Protein.—The body does not possess, to any marked degree, the power of storing nitrogenous substances. The carbonaceous moiety of the protein molecule is split off and the excess of nitrogen is quickly eliminated, chiefly as urea. It has been stated that the increased work thus demanded of the kidneys would damage them, but proof of the statement is lacking. An excess of protein in the diet frequently causes disturbances of digestion, which may or may not be referred subjectively to the alimentary tract. It appears probable that products of protein putrefaction may be absorbed and irritate the kidneys in their elimination, producing albuminuria, and perhaps ultimately causing nephritis. Some headaches appear to be caused by disorders of protein digestion or metabolism or both—at least, persistent headaches which are not due to any other discoverable cause sometimes disappear when the protein ration is reduced to a minimum and the form of the protein is changed, for example, from meat to milk. Professor Chittenden found that his rheumatism grew better under the influence of a low protein diet. Some forms of eczema disappear when meat is eliminated from the diet, and the total protein of the food is reduced (Johnston). It has not yet been proved whether an excess of protein is capable of causing arterial sclerosis.

The Carbohydrate Fat Requirement—The greater portion of the energy of the body is derived from carbohydrate and fat Since they are to a large extent interchangeable in the diet, they may be considered together While it is possible for men to live and to thrive, upon a diet of protein and fat alone, as in the case of the Eskimos, or of protein and carbohydrate alone, physiologic economy makes it expedient that the diet should contain both fat and carbohydrate In a mixed diet carbohydrate and fat possess about equal power as protein sparers As already stated, Landergren has shown that a diet furnishing half of its calories as fat and half as carbohydrate has the same power as a protein sparer as a diet of carbohydrate alone As a source of energy, therefore, in a mixed diet carbohydrate and fat are interchangeable in isodynamic amounts

The relative proportions of fat and carbohydrate in the average diet are given in the Voit and Rubner[5] standards But the proportions vary according to personal taste and the ability of the individual to digest fat Large amounts of fat in a mixed diet are difficult to digest due as Pavlov has shown to the inhibiting influence which fat exerts upon the gastric secretion

The conditions which affect the carbohydrate-fat demand in health are essentially the same as those which modify the total requirement of energy and have already been considered under the Total Food Requirement. It may be added however that the amount of fat consumed is generally less in hot climates and in hot weather The reason popularly assigned is that fat is 'heating' Rubner has shown that a greater amount of free heat is liberated during the metabolism of fat than during the metabolism of carbohydrates Physicians generally advise patients who are taking fat medicinally for example cod liver oil to discontinue it in hot weather Negroes form an exception to the rule that peoples living in warm climates eat little fat They enjoy and consume fat in relatively large quantities

Too little is known concerning the fat requirement in various diseases to justify specific recommendations The fat in the food is increased when it is desired to have a patient put on flesh Fat appears to possess along with carbohydates the power of diminishing the febrile destruction of protein

The Injurious Effects of an Excess of Fat[6]—The tolerance for fat, both as regards quantity and kind varies in health Many persons cannot take much fat or certain fats without experiencing a feeling of disgust which may amount to nausea In addition fat is capable of producing certain well-defined local disturbances of the alimentary tract,

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[5] See Table [illegible] on page [illegible]

[6] The phrase [illegible] excess of fat must be understood to relate to the tolerance of the individual rather than to the total amount of fat consumed

sons eat more meat than others, and claim that their efficiency is impaired if their usual supply is diminished Old people, as a rule, take less protein than those in active middle life

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The generally accepted ratios of protein, carbohydrate, and fat for persons at light, moderately hard, and hard work are contained in the following table

STANDARD RATIONS

	Voit	Rubner	Atwater
Light Work			
Protein grams		193	100
Fat grams		46	*
Carbohydrate grams		347	*
Calories		2 445	2 700
Moderately Hard Work			
Protein grams	118	127	125
Fat grams	56	2	*
Carbohydrate grams	00	09	*
Calories	3 055	2 968	3 400
Hard Work			
Protein grams	14	165	150
Fat grams	100	70	*
Carbohydrate grams	00	565	*
Calories	3 574	3 369	4 150

* Fat and carbohydrate must be supplied in sufficient quantities to make up the necessary energy

It must be pointed out that these figures represent averages obtained by calculations from estimations of food actually eaten by a group of individuals Such figures will of course allow for certain individual fluctuations on either side of the average figures which however, as a general measure may be accepted with considerable confidence

Method of Reckoning the Protein Fat and Carbohydrate Ratios for Diets of Definite Energy Values—In Voit s standard diet for a man at moderately hard work, approximately 16 per cent of the energy is furnished by protein 18 per cent by fat and 66 per cent by carbohydrate With the total energy value of the diet as 3 000 calories the calculation is made as follows

$$16 \text{ per cent of } 3\,000 = \frac{480}{4\,1} = 115 \text{ grams protein}$$

$$18 \text{ per cent of } 3\,000 = \frac{540}{9\,3} = 57 \text{ grams fat}$$

$$66 \text{ per cent of } 3\,000 = \frac{1980}{4\,1} = 483 \text{ grams carbohydrate.}$$

By the employment of this method, the ratios may be determined for diets of any given energy value

which may be confined to the stomach or to the intestines The commoner disorders are loss of appetite, nausea after taking food, and vomiting The effects are probably due to the inhibitory action of fat upon the gastric secretion or to the delay which it causes in the passage of the chyme into the duodenum Regurgitation of the duodenal contents into the stomach sometimes occurs and is usually followed by vomiting An excess of fat often causes diarrhea

Besides these local actions, an excess of fat is believed by many authorities to cause disorders of metabolism Persons otherwise in perfect health sometimes develop acne when the food contains much fat, but whether this results from a disturbance of metabolism, or of digestion, is not known

It has been asserted that an excess of fat is of itself capable of causing acidosis, but such a general assertion must be accepted with reserve Deprivation of carbohydrate is followed by acidosis in disease as well as in health because of the increased demand for energy which falls upon fat, and its consequent incomplete combustion Acidosis of this character has been observed to disappear spontaneously, and always disappears in healthy persons upon the addition of carbohydrate to the diet, as sufficient carbohydrate prevents the formation of ketone bodies The influence of starvation upon the development of acidosis has sometimes been overlooked and the condition has been attributed erroneously to the fat of the food or to the effect of the disease itself For example, doubt has been cast upon the causative relation of fat to the "cyclic vomiting" of children Magnus-Levy has pointed out that the cause of acidosis in diabetes mellitus is not the fat of the food but the preexisting disorder of metabolism Fat in amounts up to 250 grams a day does not cause acidosis in typhoid fever

Czerny and Steinitz believe that the majority of cases of acidosis in children are due to an excess of fat In experiments made upon children by Czerny and Keller, fat was the only foodstuff which increased the ammonia excretion in the urine Steinitz has advanced the theory that the development of acidosis with fatty acid stools in the gastro-intestinal disorders of children especially the chronic forms, is due to the loss of fixed alkalis through the intestines either in their own form or in combination with fatty acids that is, such as soaps Bahrdt considers that the increase of alkali in the stools is due to the stimulating influence of fat upon the pancreas and the intestinal secretions, that there is not enough fatty acid present to account for all of the bases According to Freund there are but few tenable arguments and no absolutely certain metabolic-chemical facts to support the clinical impression of a causative relation between fat and acidosis Yet for the present it seems advisable to be guided by clinical experience, and to withhold fat, or give it with caution, in the gastro intestinal disorders of children

Food Materials	Per Cent Protein (N × 6.25)	Per Cent Fat	Per Cent Carbohydrate	Fuel Value per Pound Calories	Fuel Value per 100 Grams Calories	100 Calorie Portion in Grams
Animal Food—Cont						
Pork Fresh						
Chops medium fat	14.0—19.0	25.0—35.0		1,580	350	28.6
Chops fat	11.0—19.0	39.0—49.0		2,145	470	21.6
Ham smoked lean	19.0—20.0	17.0—24.0		1,245	280	35.7
Ham smoked medium fat	12.0—23.0	30.0—45.0		1,940	4[illegible]0	23.6
Ham smoked, fat	12.0—19.0	42.0—57.0		2,485	550	18.2
Ham smoked average	16.5	38.8		1,945	430	23.[illegible]
Bacon medium fat	6.0—18.0	57.0—80.0		3,050	670	14.9
Sausages						
Bologna	15.0—21.0	11.0—24.0	0.2—0.5	1,095	240	41.[illegible]
Frankfort	15.0—27.0	15.0—20.0	2.0—8.6	1,170	260	38.5
Pork	7.0—19.0	28.0—[illegible]0	0.0—8.6	2,125	470	21.[illegible]
Poultry etc Fresh						
Chicken broilers	19.0—25.0	2.0—4.0		505	110	91.1
Fowls	15.0—22.0	10.0—28.0		1,045	230	43.[illegible]
Turkey	19.0—25.0	9.0—31.0		1,360	300	33.4
Chicken liver	22.4	4.2	2.4	640	140	71.4
Fish Fresh						
Bass black average	20.6	1.7		4[illegible]	100	100.0
Bass striped average	18.6	2.8		465	105	95.2
Bluefish	19.4	1.2		410	91	109.9
Cod	15.0—18.0	0.3—0.5		325	72	138.9
Halibut steaks average	18.6	5.2		565	125	80.0
Mackerel	17.0—19.0	2.0—16.0		64[illegible]	140	71.4
Salmon average	2[illegible].0	1[illegible].8		9[illegible]0	210	47.7
Shad average	18.8	9.5		750	165	60.6
Shad roe	20.9	3.8	2.6	600	135	74.1
Fish Preserved and Canned						
Cod salt boneless average	27.3	0.3		490	110	90.9
Mackerel salt boneless average	17.3	26.4		1,435	320	31.2
Sardines	23.0	19.7		1,260	280	35.7
Caviare	30.0	19.7		1,530	340	29.4
Shellfish etc Fresh						
Clams	8.0—9.0	1.0—1.2	1.0—2.0	240	53	189.0
Lobsters	1[illegible].0—2[illegible].0	1.0—2.0	0.0—1.0	390	86	116.2
Oysters	4.0—10.0	0.6—7.0	2.0—7.0	2[illegible]5	52	192.2
Scallops average	14.8	0.1	3.4	345	76	131.5
Crabs	16.6	2.0	1.2	415	92	108.6
Meats Cooked						
Beef roast	15.0—22.0	20.0—41.0		1,620	360	27.8
Beef round steak roasted	19.0—[illegible]4.0	3.0—17.0		840	185	54.1

COMPOSITION OF FOODS

Slightly modified from Atwater and Bryant U S Dept Agriculture Bull No 28 (revised edition)

Food Materials	Per Cent Protein (N × 6.25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Animal Food						
Beef Fresh						
Loin lean E.P.*	13.0—24.0	11.0—15.0		900	199	52.5
Loin medium fat	11.0—22.0	16.0—24.0		1,190	262	38.2
Loin fat	16.0—19.0	25.0—30.0		1,490	329	30.4
Loin average	19.0	19.1		1,155	254	39.4
Loin porterhouse steak	21.9	20.4		1,270	270	37.0
Loin sirloin steak	18.9	18.5		1,130	250	40.0
Loin tenderloin	12.0—18.0	17.0—30.0		1,330	290	34.5
Ribs lean	16.0—21.0	10.0—14.0		860	190	52.6
Ribs medium fat	16.0—19.0	18.0—33.0		1,450	320	31.2
Ribs fat	12.0—17.0	34.0—37.0		1,780	390	25.6
Ribs average	17.8	24.6		1,370	300	33.4
Rump lean	17.0—23.0	10.0—18.0		955	210	47.6
Rump medium fat	16.0—19.0	20.0—30.0		1,400	310	32.3
Rump fat	15.0—23.0	30.0—39.0		1,820	400	25.0
Rump average	18.7	23.1		1,325	290	34.5
Beef liver	18.0—23.0	3.0—6.0	1.0—3.5	605	135	74.0
Beef marrow	2.2	92.8		3,955	870	11.5
Beef tongue	17.0—22.0	1.0—18.0		740	165	60.6
Veal Fresh						
Leg lean	20.0—23.0	1.0—6.0		570	125	80.0
Leg medium fat	18.0—21.0	7.0—12.0		755	165	60.6
Loin lean	19.0—21.0	5.0—7.0		615	135	74.1
Loin medium fat	18.0—20.0	10.0—13.0		825	180	55.6
Loin fat	18.0—19.0	18.0—19.0		1,145	250	40.0
Loin average	19.9	10.0		790	175	57.2
Rib medium fat	20.0—22.0	3.0—9.0		640	140	71.4
Rib fat	16.0—20.0	11.0—31.0		1,160	260	38.4
Veal kidney average	16.9	6.4		585	130	77.0
Veal liver average	19.0	5.3		575	125	80.0
Lamb Fresh						
Leg	15.0—18.0	15.0—27.0		1,300	290	34.5
Loin	17.0—20.0	25.0—35.0		1,540	340	29.4
Mutton Fresh						
Leg lean	19.0—20.0	12.0—13.0		890	195	51.3
Leg medium fat	17.0—10.0	15.0—22.0		1,105	240	41.7
Leg average	18.7	17.5		1,085	240	41.7
Loin medium fat	14.0—20.0	26.0—38.0		1,695	375	26.7
Loin free fat removed	23.7	18.5		1,225	270	37.0
Kidney	16.5	3.2		440	97	103.0
Liver average	23.1	9.0	5.0	905	200	50.0

* Edible Portion

Food Material	Per Cent Protein (N × 6.25)	Per Cent Fat	Per Cent Carbohydrate	Fuel Value per Pound Calories	Fuel Value per 100 Grams Calories	100 Calorie Portions Grams
Animal Food—Cont						
Pork Fresh						
Chops medium fat	14.0—19.0	2[illegible].0—35.0		1,590	350	28.6
Chops fat	11.0—19.0	39.0—49.0		2,145	470	21.6
Ham smoked lean	19.0—20.0	1[illegible].0—24.0		1,245	280	35.7
Ham smoked medium fat	1[illegible].0—23.0	30.0—45.0		1,940	430	23.6
Ham smoked fat	1[illegible].0—19.0	42.0—57.0		2,485	550	18.2
Ham smoked average	16.5	38.8		1,945	4[illegible]0	23.6
Bacon medium fat	6.0—18.0	5[illegible].0—80.0		3,030	670	14.9
Sausages						
Bologna	15.0—21.0	11.0—24.0	0.2—0.5	1,095	240	41.7
Frankfort	15.0—[illegible]7.0	1[illegible].0—2[illegible].0	2.0—8.6	1,170	260	38.5
Pork	7.0—19.0	[illegible].0—5[illegible].0	0.0—[illegible].6	[illegible]	4[illegible]0	21.6
Poultry etc Fresh						
Chicken broilers	19.0—[illegible]5.0	2.0—4.0		505	110	91.1
Fowls	15.0—[illegible].0	10.0—28.0		1,045	230	43.5
Turkey	19.0—25.0	9.0—31.0		1,360	300	33.4
Chicken liver	22.4	4.2	2.4	640	140	71.4
Fish Fresh						
Bass black average	20.6	1.7		455	100	100.0
Bass striped average	18.6	2.8		465	105	95.2
Bluefish	19.4	1.2		410	91	109.9
Cod	15.0—18.0	0.3—0.5		325	72	138.9
Halibut steaks average	18.6	5.2		565	125	80.0
Mackerel	17.0—19.0	2.0—16.0		64	140	71.4
Salmon average	22.0	1[illegible].8		950	210	4[illegible].7
Shad average	18.8	9.5		750	165	60.6
Shad roe	20.9	3.8	2.6	600	1[illegible]5	74.1
Fish Preserved and Canned						
Cod salt boneless average	27.3	0.3		490	110	90.9
Mackerel salt boneless average	17.3	26.4		1,435	320	31.2
Sardines	23.0	19.7		1,260	280	35.7
Caviare	30.0	19.7		1,530	340	29.4
Shellfish etc. Fresh						
Clams	8.0—9.0	1.0—1.2	1.0—2.0	240	53	189.0
Lobsters	12.0—2[illegible].0	1.0—2.0	0.0—1.0	390	86	116.2
Oysters	4.0—10.0	0.6—7.0	2.0—[illegible].0	235	[illegible]2	10[illegible].2
Scallops average	14.8	0.1	3.4	345	76	131.5
Crabs	16.6	2.0	1.2	415	92	108.6
Meats Cooked						
Beef roast	15.0—29.0	20.0—41.0		1,620	360	27.8
Beef round steak roasted	19.0—34.0	3.0—17.0		840	185	54.1

Composition of Foods

Slightly modified from Atwater and Bryant U S Dept Agriculture Bull No 28 (revised edition)

Food Materials	Per Cent Protein (N x 6 25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Animal Food						
Beef Fresh						
Loin lean E.P.*	13.0—24.0	11.0—15.0		900	199	[illegible]5
Loin medium fat	11.0—22.0	16.0—24.0		1 190	262	38.2
Loin fat	16.0—19.0	2[illegible].0—30.0		1 490	329	30.4
Loin average	19.0	19.1		1 155	254	39.4
Loin porterhouse steak	21.9	20.4		1 270	270	37.0
Loin sirloin steak	18.9	18.5		1 130	250	40.0
Loin tenderloin	12.0—18.0	17.0—25.0		1 330	290	34.5
Ribs lean	16.0—21.0	10.0—14.0		870	190	52.6
Ribs medium fat	18.0—19.0	18.0—33.0		1 450	370	31.2
Rib fat	12.0—17.0	34.0—37.0		1 780	390	25.6
Rib average	17.8	24.6		1 3[illegible]0	300	33.4
Rump lean	17.0—23.0	10.0—18.0		965	210	47.6
Rump medium fat	16.0—19.0	20.0—30.0		1 400	310	32.3
Rump fat	15.0—23.0	33.0—39.0		1 8[illegible]0	400	25.0
Rump average	18.7	23.1		1 325	290	34.5
Beef liver	18.0—23.0	3.0—6.0	1.0—3.5	605	135	74.0
Beef marrow	2.2	92.8		3 955	8[illegible]0	11.5
Beef tongue	17.0—2[illegible].0	1.0—18.0		740	165	60.6
Veal Fresh						
Leg lean	20.0—23.0	1.0—6.0		5[illegible]0	125	80.0
Leg medium fat	18.0—21.0	7.0—12.0		755	165	60.6
Loin lean	19.0—21.0	5.0—7.0		615	135	74.1
Loin medium fat	18.0—20.0	10.0—13.0		825	180	55.6
Loin fat	18.0—19.0	18.0—19.0		1 145	250	40.0
Loin average	19.9	10.0		790	175	57.2
Rib medium fat	20.0—2[illegible].0	3.0—9.0		640	140	71.4
Rib fat	16.0—20.0	11.0—31.0		1 160	260	38.4
Veal kidney average	16.9	6.4		585	130	77.0
Veal liver average	19.0	5.3		575	125	80.0
Lamb Fresh						
Leg	15.0—18.0	15.0—27.0		1 300	290	34.5
Loin	17.0—20.0	25.0—35.0		1 540	340	29.4
Mutton Fresh						
Leg lean	19.0—20.0	12.0—13.0		890	195	51.3
Leg medium fat	17.0—10.0	15.0—22.0		1 105	240	41.7
Leg average	18.7	17.5		1 085	240	41.7
Loin medium fat	14.0—20.0	26.0—38.0		1 695	375	26.7
Loin free fat removed	23.7	18.5		1 225	270	37.0
Kidney	16.5	3.2		440	97	103.0
Liver average	23.1	9.0	5.0	905	200	50.0

* Edible Portion

Food Material	Per Cent Protein (N × 6.25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Animal Food—Cont.						
Dairy Products—Cont.						
Milk, whole	3.3	4.0	5.0	325	72	138.9
Whey	1.0	0.3	5.0	125	28	357.0
Woman's milk *	2.01	3.74	6.37	310	68	147.1
Goat's milk *	3.76	4.07	4.64	315	69	144.0
Cream *	2.5	18.5	4.5	935	206	48.6
Cream, very rich, centrifugal †	2.5	40.0	3.0	1,780	393	25.4
Cream, ordinary, centrifugal †	3.0	20.0	3.9	925	204	49.1
Cream, ordinary, gravity †	3.0—3.2	16.0—20.0	3.9—4.0	890	196	51.0
Milk, ordinary, whole †	3.5	4.0	4.5	320	70	143.0
Top from one quart of whole milk †						
Top 16 oz. or upper one half	3.4	7.0	4.5	440	98	100.2
Top 11 oz. or upper one third	3.3	10.0	4.3	560	124	80.7
Top 8 oz. or upper one fourth	3.3	13.0	4.2	670	148	67.6
Top 6 oz. or upper one fifth	3.2	16.0	4.0	80	178	56.2
Whey from whole milk *	0.94	0.90	5.5	115	25	400.0
Whey from fat free milk ‡	1.17	0.04	5.4	120	26	3[illegible]0.5
Matzoon or Zoolak †	3.5	3.5	3.7	280	62	161.2
Gelatin	89.0—91.0			1,705	380	26.3
Calf's foot jelly	4.3		17.4	40	90	111.1
Lard, refined		100.0		4,220	930	10.7
Lard, unrefined	2.0—3.0	94.0—96.0		4,010	890	11.2
Oleomargarine	1.2	83.0		3,525	780	12.8
Beef juice	4.9	0.6		115	25	400.0
Vegetable Food						
Barley meal and flour	9.0—13.0	1.5—3.2	70.0—74.0	1,640	360	27.8
Barley, pearled	7.0—10.0	0.7—1.5	70.0—78.0	1,650	360	27.8
Barley water †	0.09	0.05	1.6	36	8	1250
Buckwheat flour	4.0—10.0	0.5—2.3	71.0—81.0	1,620	360	27.8
Buckwheat preparation, farina and groat, average	10.9	0.4	84.0	1,660	370	27.1
Corn meal, unbolted	8.0—9.0	4.5—5.2	[illegible]	1,730	380	26.3
Corn flour	6.0—8.0	1.0—2.0	[illegible]7.0—80.0	1,645	360	27.8

* From U. S. Dept. of Agriculture Farmers' Bulletin No. 363.
† From Holt, The Diseases of Infancy and Childhood, New York, 1904.
‡ From Analyses by Ad[illegible]e.

Food Materials	Per Cent Protein (N × 6.25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portions in Grams
Animal Food—Cont						
Meats Cooked—Cont						
Loin steak tenderloin broiled	20.0—27.0	12.0—36.0		1,300	290	34.5
Corn beef canned	21.0—35.0	12.0—31.0		1,280	280	35.7
Tongue canned	11.0—23.0	18.0—23.0		1,340	300	33.3
Lamb Cooked						
Chops broiled	19.0—25.0	24.0—35.0		1,665	370	27.1
Leg roast	19.7	12.7		900	200	50.0
Mutton Cooked						
Leg roast	23.0—28.0	20.0—25.0		1,420	310	32.3
Pork Cooked						
Ham roast	18.0—26.0	17.0—24.0		1,210	281	35.6
Ham smoked boiled	18.0—22.0	8.0—37.0		1,320	290	34.5
Ham smoked fried	22.2	33.2		1,815	400	25.0
Ham luncheon cooked	22.5	21.0		1,305	290	34.5
Poultry Cooked						
Capon	27.0	11.5		985	220	45.5
Chicken fricasseed	17.6	11.5	2.4	855	190	52.6
Turkey roast	27.8	18.4		1,295	290	34.5
Fish Cooked						
Bluefish cooked	25.9	4.5		670	150	66.6
Spanish mackerel broiled	23.7	6.5		655	145	69.0
Dairy Products						
Eggs hen's raw F P	11.6—16.0	8.6—15.1		720	160	62.5
Eggs hen's boiled	10.0—15.6	9.1—14.7		765	170	58.8
Eggs hen's average	13.3	11.2		742	165	60.6
Eggs boiled whites	11.6—14.8	0.0—0.3		250	55	182.0
Eggs boiled yolks	15.3—16.8	32.2—34.4		1,705	380	26.3
Butter	1.0	85.0		3,605	800	12.5
Milk buttermilk	3.0	0.5	4.8	165	36	278.0
Cheese American	28.8	35.9	0.3	2,055	450	22.2
Cheese Cheddar	27.7	36.8	4.1	2,145	470	21.3
Cheese Cottage	16.0—20.0	0.4—1.0	3.7—4.9	510	115	87.0
Cheese Dutch	30.0—45.0	16.0—19.0		1,435	320	31.2
Cheese full cream	18.0—37.0	24.0—45.0	1.2—4.0	1,950	430	23.2
Cheese Swiss	26.0—29.0	33.0—37.0	0.9—1.7	2,010	440	22.7
Koumiss	2.6—3.0	1.7—2.4	5.1—5.9	240	53	189.0
Milk sweetened condensed	6.0—10.0	0.4—10.6	44.0—57.0	1,590	340	29.4
Milk unsweetened condensed (evaporated milk)	8.0—10.0	8.0—10.0	10.0—12.0	780	170	58.8
Milk skimmed	3.4	0.3	5.1	170	38	263.0

Food Material	Per Cent Protein (N x 6.25)	Per Cent Fat	Per Cent Carbohydrate	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Vegetable Food—Cont.						
Cookies, all analyses, average	7.0	9.[illegible]	73.7	1910	420	23.8
Ginger snaps	5.8—7.3	2.3—15.4	71.9—80.8	1895	420	23.8
Macaroons	3.1—10.6	9.6—1[illegible]	57.1—71.4	1975	435	23.0
Doughnuts	5.1—[illegible]	16.4—25.7	45.8—63.2	2000	440	22.8
Pie, apple	2.6—3.8	7.7—11.3	40.3—46.2	1,210	280	35.7
Pie, custard	4.2	6.3	26.1	830	180	55.6
Pie, mince	4.5—7.[illegible]	9.7—14.5	30.4—44.0	1355	295	34.0
Pie, squash	4.4	8.4	21.7	840	185	54.1
Pudding, Indian meal	5.[illegible]	4.8	27.5	815	180	55.6
Pudding, rice custard	4.0	4.6	31.4	8[illegible]5	180	55.6
Pudding, tapioca	2.8—4.2	2.3—4.8	21.9—38.1	720	160	62.5
Pudding, tapioca with apples	0.3	0.1	29.3	5[illegible]	125	80.0
Candy			96.0	1785	395	25.3
Honey	0.2—1.1		73.3—85.4	1[illegible]90	350	28.6
Molasses	0.0—5.1	0.0—0.[illegible]	58.8—76.7	1290	285	35.1
Starch, arrowroot			9[illegible]	181[illegible]	400	25.0
Starch, cornstarch			90.0	1675	370	27.1
Starch, tapioca	0.2—0.6	0.0—3.0	86.6—89.0	1650	365	27.5
Sugar, coffee or brown			95.0	1765	390	25.6
Sugar, granulated			100.0	1860	410	24.4
Sugar, maple			74.0—95.2	1[illegible]40	340	29.4
Syrup, maple			45.9—81.9	1330	295	34.0
Vegetables						
Artichokes	2.2—2.9	0.1—0.2	15.3—18.3	365	81	123.3
Asparagus, cooked	2.1	3.3	2.2	220	49	204.0
Beans, butter, green, E. P.	9.4	0.6	29.1	740	165	60.6
Beans, dried	19.9—26.[illegible]	[illegible]4—3.1	57.2—66.5	1605	355	28.1
Beans, lima, dried	12.8—24	0.6—1.9	61.6—70.1	162[illegible]	360	27.8
Beans, lima, fresh, E. P.	3.2	0.3	9.9	255	56	178.7
Beans, string, cooked, E. P.	0.8	1.1	1.9	95	21	47[illegible].0
Beans, string, fresh, E. P.	1.7—2.8	0.4	12.6	300	66	151.5
Beets, cooked, E. P.	2.3	0.1	7.4	185	41	244.0
Beets, fresh, E. P.	0.9—3.0	0.1—0.2	3.8—16.3	215	47	216.0
Cabbage, E. P.	0.2—2.9	0.1—0.[illegible]	3.4—8.0	145	42	238.0
Carrots, fresh, E. P.	0.[illegible]—2.0	0.0—0.[illegible]	6.5—13.8	210	46	218.0
Cauliflower	1.6—2.0	0.2—8.0	3.4—6.0	140	31	323.0
Celery, E. P.	1.0—1.4	0.1—0.2	3.0—4.6	85	19	526.0
Corn, green, E. P.	2.8—3.[illegible]	1.0—1.1	14.1—22.6	470	105	95.4
Cucumbers, E. P.	0.5—0.9	0.1—0.5	2.2—4.0	80	18	556.0
Lentil, dried	24.5—26.6	0.7—1.5	56.6—59.[illegible]	1620	360	27.8

Food Materials	Per Cent Protein (N x 6.25)	Per Cent Fat	Per Cent Carbohydrate	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Vegetable Food—Cont						
Corn meal granular	7.0—12.0	1.0—5.0	68.0—80.0	1,655	370	27.1
Hominy raw	6.0—9.0	0.2—1.0	77.0—81.0	1,650	360	27.8
Hominy cooked	2.2	0.2	17.8	380	84	119.0
Oatmeal raw	13.0—21.0	6.0—9.0	64.0—70.0	1,860	410	24.4
Oatmeal boiled	2.8	0.5	11.5	285	63	159.0
Oatmeal gruel	0.9—1.6	0.2—0.5	3.0—10.0	155	34	294.0
Oatmeal water	0.4—0.9	0.0—0.1	1.3—4.5	70	15	666.6
Rice	9—11.3	0.1—0.7	75.4—81.9	1,630	360	27.8
Rice boiled	1.6—5.0	0.0—0.1	15.5—41.9	510	115	86.9
Rye flour	4.9—8.8	0.2—1.3	77.0—80.2	1,6 0	360	27.8
Wheat flour	12.2—14.6	2.1—1.5	69.5—77.0	1,675	370	27.1
Wheat flour patent roller process	8.4—14.7	0.3—1.6	70.3—80.0	1,660	370	27.1
Farina	10.4—11.7	0.8—3.8	74.6—78.5	1,655	370	27.1
Shredded wheat	9.6—11.4	1.1—1.6	75.0—79.7	1,700	380	26.3
Macaroni	7.9—16.0	0.0—4.9	67.2—78.4	1,665	370	27.1
Bread brown as purchased	5.0—5.8	1.2—2.4	43.6—50.7	1,050	230	43.5
Bread corn (johnny cake)	6 —10.1	2.3—9.8	40.3—54.3	1,205	280	35.7
Bread rye	6.4—11.1	0.1—1.4	45.6—65.8	1,180	260	38.4
Bread gluten	8.2—11.1	0.7—2.4	44.6—53.0	1,160	260	38.4
Bread graham	6.8—10.9	0.4—3.8	38.6—55.1	1,210	270	37.1
Roll plain	8.6—11.0	0.4—9.4	56.7—64.7	1,470	320	31.2
Roll all analyses average	8.9	4.1	56.7	1,395	310	32.3
Toasted bread	10.6—12.8	0.6—3.2	56.7—67.1	1,420	310	32.3
Bread white homemade	6.8—11.0	0.4—3.5	47.6—58.0	1,225	270	37.1
Bread white all analyses average	9.2	1.3	53.1	1,215	270	37.1
Bread whole wheat	8.1—11.7	0.4—2.7	37.2—56.2	1,140	250	40.0
Zwieback	8.6—11.7	8.1—11.3	72.1—74.2	1,970	435	23.0
Crackers Boston split	10.7—11.3	9.9	68.8—73.4	1,885	415	24.1
Crackers cream	8.6—11.9	10.7—13.8	68.0—72.4	1,990	440	22.8
Crackers graham	7.4—14.4	1.1—13.6	69.7—77.2	1,955	430	23.2
Crackers oatmeal	10.4—13.1	8.5—13.7	68.3—69.6	1,970	435	23.0
Crackers saltines	9.9—11.2	12.7—12.8	67.1—69.9	2,005	440	22.8
Cake chocolate layer	6.2	8.1	64.1	1,650	365	27.5
Cake coffee	4.9—9.0	4.7—10.5	2.4—78.8	1,625	360	27.8
Cake cup	5.2—6.6	2.5—15.6	63.2—73.8	1,765	390	25.6
Cake frosted	5.0—7.5	7.5—10.6	58.3—71.0	1,695	375	26.7
Gingerbread	5.4—6.3	8.4—9.5	62.3—64.7	1,670	370	27.1
Cake sponge	5.7—7.3	6.4—13.0	57.3—71.1	1,795	395	25.3
Cake all analyses except fruit cake average	6.3	9.0	63.3	1,675	370	27.1

Food Materials	Per Cent Protein (N x 6 25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portion in Grams
Fruits						
Apples	0 1—0 8	0 1—1 4	8 8—21 3	290	64	156 1
Apricots E P	1 1		13 4	270	60	166.8
Banana yellow F P	1 0—1 [illegible]	0 0—1 4	16 3—29 8	460	100	100 0
Blackberries	0 9—1 5	0 [illegible]—2 9	7 [illegible]—16 7	2[illegible]0	60	166 8
Cherries E P	0 7—1 1	0 8—0 [illegible]	11 4—20 6	36[illegible]	81	123 3
Cranberries	0 4—0	0 4—0 9	9 3—10 9	215	47	216 0
Grapes E P	1 3	1 6	19 [illegible]	4[illegible]0	99	111 1
Lemons E P	0 8—1 1	0 1—1 5	8 2—9 0	205	4[illegible]	226 0
Lemon juice			9 8	180	40	250 0
Oranges E P	0 8—1 1	0 1—0 3	11 6—18	240	[illegible]3	189 0
Peaches E P	0 4—0 [illegible]	0 1—0 1	9 3—9 4	190	42	238 0
Pears E P	0 6—0 6	0 1—0 8	14 1—14 [illegible]	295	65	154 0
Plums F P average	1 0		20 1	39[illegible]	8[illegible]	115 0
Prune F P average	0 9		18 9	370	82	1[illegible]2 0
Raspberries red F P	1 0		12 6	255	56	178 5
Strawberries F P	0 6—1 [illegible]	0 4—1 1	4 4—1[illegible] 3	180	40	250 0
Watermelon E P	0 3—0 [illegible]	0 1—0 2	6 5—6 9	140	31	323 0
Fruits Dried						
Apples	1 [illegible]—[illegible]	0 1—[illegible]0	48 6—80 9	1 350	300	33 4
Currant Zante	1 0—4 7	0 4—4 7	60 0—85 3	1 495	330	30 3
Figs	2 6—	0 3—0 3	68 3—83 1	1 475	3[illegible]5	30 8
Prunes F P	1 4—3 [illegible]		68 1—78 6	1 400	310	3[illegible] 3
Fruits Canned etc						
Raisins E P	2 3—3 0	0 5—7 [illegible]	71 3—78 8	1 605	3[illegible]	[illegible]8 1
Apple sauce	0 2	0 8	37 2	730	160	6[illegible] 5
Marmalade (orange peel)	0 6	0 1	84 5	1 [illegible]85	350	[illegible]8 6
Strawberries stewed	0 7		24 0	460	100	100 0
Nuts						
Almond F P	16 6—[illegible] 3	48 9—60 0	19 8—21 4	3 030	6[illegible]0	14 9
Brazil nut F P	17 0	66 8	7 0	3 [illegible]6[illegible]	7[illegible]0	13 9
Chestnut fresh F P	4 1—8 0	0—10 8	36 9—[illegible]4 0	1 1[illegible]5	2[illegible]0	40 0
Coconut without milk	3 6	31 7	1[illegible] 5	1 730	3[illegible]0	[illegible]6 3
Filbert F P	1[illegible] 6	[illegible]3	13 0	3,290	[illegible]	13 8
Hickory nuts F P	15 4	[illegible] 4	11 4	3 345	740	13 5
Peanuts F P	19 [illegible]—[illegible]9 1	3[illegible] 3—48 8	1[illegible] 3—10 4	[illegible]	[illegible]63	17 7
Peanut butter	[illegible]9 3	46	17 1	2 8[illegible]5	6[illegible]	16 0
Pecans unpolished F P	9 6	70 5	15 3	3 435	760	13 1
Walnuts California black E P	[illegible]4 9—30 3	4[illegible]—[illegible]7 8	[illegible]4—16 1	3 10[illegible]	68[illegible]	14 6
Miscellaneous						
Chocolate	1[illegible]—13 4	47 1—[illegible]0.2	[illegible]—33 8	[illegible]860	[illegible]30	15 9
Cocoa	[illegible]—[illegible]	[illegible]1—31 [illegible]	3[illegible] 3—40 [illegible]	[illegible]	[illegible]10	19 6
Beef soup	[illegible]7—6 [illegible]	0 3—0 5	0 0—2 [illegible]	1[illegible]0	26	[illegible]84 0

Food Materials	Per Cent Protein (N x 6.25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portions in Grams
Vegetables—Cont.						
Lettuce E P	0.7—1.8	0.1—0.6	1.6—4.9	90	20	500.0
Mushrooms	1.7—6.0	0.2—0.0	2.4—20.3	210	46	218.0
Onions fresh E P	0.2—4.4	0.1—0.8	4.2—15.5	225	50	200.0
Onion cooked prepared	1.2	1.8	4.9	190	42	238.0
Parsnips	1.4—1.9	0.2—0.8	8.0—17.0	300	66	151.5
Peas dried	20.4—28.0	0.8—1.3	58.0—67.4	1655	365	2[illegible]
Peas green E P	4.4—8.0	0.[illegible]—0.6	13.4—18.9	465	105	95.4
Peas green cooked	6.7	3.4	14.6	540	120	83.3
Potatoes raw or fresh E P	1.1—3.0	0.0—0.2	13.5—27.4	385	85	117.8
Potatoes cooked boiled	1.8—3.1	0.0—0.4	16.1—26.5	440	97	103.1
Potatoes cooked chips	6.0—7.6	35.5—44.9	42.7—50.6	2675	590	16.9
Potatoes cooked, mashed and creamed	2.0—3.6	1.0—4.5	13.9—22.4	505	110	90.9
Potatoes sweet raw or fresh E P	0.4—3.7	0.2—1.4	17.1—49.1	570	125	80.0
Potatoes cooked and prepared sweet	3.0	2.1	42.1	925	200	50.0
Sweet cassava *	1.1	0.2	30.2	610	135	74.1
Cassava starch *	0.5	0.1	88.8	1625	360	27.8
Cassava bread *	9.1	0.3	79.0	1650	365	27.4
Cassava cakes or wafers *	1.1	0.2	85.2	1680	370	27.0
Taro *	1.8	0.2	23.2	47[illegible]	105	95.3
Yams *	1.8	0.2	23.2	4[illegible]5	105	95.3
Yautia tubers *	2.2	0.2	26.1	535	120	83.3
Radishes E P	0.5—3.0	0.0—0.3	3.4—8.3	135	30	334.0
Spinach fresh	1.8—2.4	0.2—0	3.1—3.4	110	24	417.0
Spinach cooked	2.1	4.1	2.6	260	57	175.4
Squash E P	0.6—3.1	0.1—1.4	3.5—16.5	215	47	216.0
Tomatoes fresh	0.3—1.3	0.2—1.4	2.2—6.5	105	23	435.0
Turnips	0.7—3.9	0.1—0.4	2.8—23.8	185	41	244.0
Vegetables Canned						
Asparagus	0.9—2.4	0.0—0.2	2.2—4.1	85	19	526.0
Beans baked	5.1—8.1	0.3—6.8	13.1—23.2	600	135	74.0
Beans string	0.6—4.0	0.0—0	2.0—13.5	95	21	477.0
Beans lima	3.2—5.6	0.2—0.6	10.5—17.9	360	79	126.7
Corn green	2.0—3.7	0.5—1.9	9.8—2[illegible].8	455	100	100.0
Peas green	1.6—6.1	0.0—0.8	4.9—17.4	2[illegible]5	56	178.5
Succotash	2.9—4.4	0.7—1.7	14.9—22.4	455	100	100.0
Tomatoes	0.3—1.7	0.1—0.3	1.4—8.1	105	23	435.0
Catsup tomato	1.1—2.0	0.1—0.4	8.5—16.1	265	58	172.3
Olives green E P	1.1	27.6	11.6	1400	310	32.3
Pickles cucumber	0.4—0.7	0.1—0.5	1.3—5.4	70	15	666.6

From Bulletin No. [illegible]9 Dept. of Agriculture

PERCENTAGE COMPOSITION OF TRUE AND SO CALLED GLUTEN FLOUR

From Wiley Foods and Their Adulteration Philadelphia 1911

Name	Per Cent Protein	Per Cent Fat	Per Cent Carbohydrate
Gum glutin (Hoyt's)	31.90	1.55	54.1[illegible]
Educator standard gluten flour	26.40	1.67	[illegible]9.38
Gluten flour 40 per cent	40.25	1.18	47.42
	41.10	1.10	47.90
Self raising gluten flour 40 per cent	38.70	1.30	50.10
Pure gluten flour	78.80	0.90	12.60
20 per cent gluten flour	21.00	0.70	68.20
Pure gluten flour gluto ac	35.[illegible]0	0.60	[illegible].00
Gluten food	85.40	0.[illegible]6	3.69
Protosac	36.[illegible]0	0.86	51.03
Washed gluten flour	6[illegible].40	0.91	[illegible]9.51
Glutosac	34.06	1.57	52.13
Diabetic biscuit flour	75.[illegible]	8.96	5.89
Plasmon meal	[illegible]8.6	2.72	0
Aleuronat	86.10	0.[illegible]1	4.00
	73.65	0.[illegible]4	14.55
Roborat	82.20	3.67	3.00
Wheat protein	84.10	1.40	4.80
Energin from rice	83.70	4.54	0.67
Vegetable gluten	[illegible]1.3[illegible]	1.[illegible]5	28.[illegible]3
Casoid flour	85.[illegible]	0.50	0
Sanitas nut meal	29.00	51.66	1[illegible].13
Soy bean meal	39.87	19.06	25.09
Almond meal	50.[illegible]	15.63	15.90
Gluten flour	11.37	0.[illegible]0	74.38
Gluten flour	1[illegible].50	2.60	70.80
Diabetic flour	12.00	0.4[illegible]	76.45
Jireh diabetic flour	14.[illegible]0	2.21	71.95
Special diabetic flour	14.[illegible]	2.96	67.47
Gluten flour	13.30	1.0	7[illegible].11
Gluten flour	16.40	3.1[illegible]	[illegible]0.60

the muscle fibers. While heat coagulates the albumins of meat and it is thought renders them slightly less digestible this effect is probably more than offset by the above-mentioned advantages, unless the meat be cooked too long

Vegetables consist for the most part of starch which is inclosed within cellulose walls Cellulose is practically undigested by man, and much of the starch of raw vegetables escapes from the body in the feces Moreover, raw starch itself is difficult of digestion During the process of cooking the starch grains swell, burst the cell walls and become softer In addition starch is converted partly to dextrin this occurs both in moist and dry heat

Food Materials	Per Cent Protein (N x 6 25)	Per Cent Fat	Per Cent Carbohydrates	Fuel Value per Pound in Calories	Fuel Value per 100 Grams in Calories	100 Calory Portions in Grams
Miscellaneous—Cont.						
Bean soup	3 2	1 4	9 4	295	65	154 0
Chicken soup	10 5	0 8	2 4	275	61	164 0
Clam chowder	0 7— 2 9	0 5— 1 1	2 5—11 0	195	43	236 0
Meat stew	3 7— 5 6	2 0— 6 4	4 3— 7 9	370	82	122 0
Soups Canned						
Asparagus cream of	2 5	3.2	5.5	285	63	159 0
Bouillon	1 7— 2 6	0 0— 0 2	0 1— 0 3	50	11	909 0
Celery cream of	2 1	2 8	5 0	250	55	182 0
Chicken gumbo	3 0— 4 6	0 2— 1 7	3 8— 5 5	195	43	236 0
Chicken soup	3 2— 3 9	0 0— 0 9	1 2— 1 7	100	22	455 0
Mock turtle	4 5— 5 9	0 5— 1 3	1 6— 3 9	185	41	244 0
Oxtail	3 9— 4 1	0 5— 2 1	4 2— 4 3	210	46	218 0
Pea soup	1 5— 5 8	0 0— 1 0	5 1—11 1	235	52	192 5
Tomato soup	1 7— 1 9	0 9— 1 2	5.3— 6 0	185	41	244 0

THE EFFECTS OF COOKING UPON FOOD[7]

The practice of cooking food is universal All existing races follow the custom, at least as regards part of their food, and archeological researches indicate that the art of cooking extended far into prehistoric times Cooking plays an important part in the preparation of food for human consumption Substances which in their natural state are insipid and nearly, or quite, indigestible become valuable foods when subjected to the processes of cooking

The objects sought in the cooking of meats and vegetables are essentially similar They are as follows

1 To develop flavor and improve the appearance of the food

Foods which are attractive in appearance, of pleasant aroma, and savory taste stimulate the secretion of the 'appetite juice' and thus indirectly become more digestible

2 To increase its digestibility

Cooking produces both physical and chemical changes in the food It is more important in the case of vegetables than in the case of meats Both are rendered more digestible

In the process of cooking the connective tissue of meat is softened and in part converted to gelatin In consequence, mastication is easier and more complete, thus insuring freer access of the digestive juices to

[7] In the preparation of this section the author has derived much assistance from U S Dept of Agriculture Bulls Nos 43 67 and 102 and Farmers Bulls. Nos 34 and 389

Percentage Composition of True and So Called Gluten Flour

From Wiley Foods and Their Adulteration Philadelphia 1911

Name	Per Cent Protein	Per Cent Fat	Per Cent Carbohydrates
Gum glutin (Hoyt's)	31 80	1 55	54 15
Educator standard gluten flour	96 40	1 67	59 38
Gluten flour 40 per cent	40 25	1 18	47 42
	41 10	1 10	47 90
Self raising gluten flour 40 per cent	38 70	1 50	0 10
Pure gluten flour	78 80	0 90	12 60
20 per cent gluten flour	21 00	0 70	68 20
Pure gluten flour glutosac	35 20	0 60	55 00
Gluten food	85 40	0 56	3 69
Protosac	36 60	0 86	51 03
Washed gluten flour	62 40	0 91	29 51
Glutosac	34 00	1 57	52 13
Diabetic biscuit flour	75 25	8 96	5 89
Plasmon meal	78 65	2 72	0
Aleuronat	86 10	0 51	4 00
	73 65	0 24	14 5
Roborat	82 20	3 67	3 00
Wheat protein	84 10	1 40	4 80
Energin from rice	83 40	4 54	0 67
Vegetable gluten	61 37	1 55	28.23
Casoid flour	85 50	0 50	0
Sanitas nut meal	29 00	51 66	12 13
Soy bean meal	39 87	19 06	25 09
Almond meal	50 12	15 63	15 90
Gluten flour	11 37	0 90	74 38
Gluten flour	15 50	2 60	70 80
Diabetic flour	12 00	0 40	76 45
Jireh diabetic flour	14 30	2 21	71 95
Special diabetic flour	14 2	2 96	67 47
Gluten flour	13 30	1 0	2 11
Gluten flour	16 40	3 15	70 60

the muscle fibers While heat coagulates the albumins of meat and, it is thought renders them slightly less digestible this effect is probably more than offset by the above-mentioned advantages unless the meat be cooked too long

Vegetables consist for the most part of starch which is inclosed within cellulose walls Cellulose is practically undigested by man and much of the starch of raw vegetables escapes from the body in the feces Moreover, raw starch itself is difficult of digestion During the process of cooking the starch grains swell burst the cell walls and become softer In addition starch is converted partly to dextrin this occurs both in moist and dry heat

Except for the development of flavor, fats are probably affected but little by the process of cooking unless they are scorched

3 To destroy parasites and bacteria

When meat is taken only from healthy animals and is properly inspected, there is little danger from parasites or bacteria But these precautions are not always followed especially in the case of meats which are sold to the poor, therefore, meats of doubtful origin should always be thoroughly cooked

Vegetable foods, likewise, may carry infection The typhoid bacillus, for example, may enter the body upon green vegetables which have been washed or grown in polluted water

Cooking Meats—The various methods of cooking meats may be grouped under two headings

1 Methods which are intended to prevent the loss of the juices of the meat, such as roasting and broiling By these methods the meat is heated rapidly, the surface albumin coagulated, and the juices of the meat retained

2 Methods which permit the loss of the juices, such as boiling and stewing With these methods the meat is heated slowly, and the juices escape to a greater or lesser extent

Losses in Cooking Meat—Meat loses in weight whatever the method of cooking This is due to the driving off of water, and it follows that a given weight of cooked meat holds a higher percentage of nutriment than the same weight of raw meat According to Grindley, the loss in weight amounts to one-fifth to one-third, whether the meat be boiled or roasted The loss in the solids of the meat is greatest when it is boiled or stewed, and the longer it is cooked the greater the loss The loss may reach from 3 to 20 per cent

While meat which is boiled gives up most of its flavor to the water and becomes insipid it loses very little of its nutriment It is the rich taste of beef tea which gave rise to the fallacy that it contained the nutritious elements of the meat in quantity

Cooking Vegetables and Losses Incurred—Losses occur in the cooking of vegetables, which are comparable to, but perhaps not so important as those which occur in the cooking of meats by methods which do not retain the juices The losses in the cooking of vegetables depend largely upon the method employed, and concern chiefly the sugars and salts which are soluble in water, though nitrogen also is lost The losses to which potatoes, carrots, and cabbage, selected as types, are subject have been studied by Snyder His experiments showed the following results

1 That in order to obtain the highest food value, potatoes should not be peeled before cooking

2 When peeled, the least loss occurs if the potatoes are put directly into boiling water, though the loss is still considerable

3 When peeled and soaked in cold water before cooking, the loss may reach one-fourth of the protein matter

Similar losses may occur in the cooking of carrots and cabbage

Breadmaking —Snyder and Voorhees investigated the losses of flour in breadmaking They affect both the nitrogen and carbohydrate The loss in nitrogen may reach 1 45 per cent The carbohydrate loss is caused by the fermentation which the bread undergoes in "rising" (yeast cells) The authors state that the losses in breadmaking need not exceed 2 per cent of the flour used and may be reduced to 1 1 per cent

Cereal Breakfast Foods —The importance of cereal breakfast foods has been shown especially by the investigations of Woods and Snyder These authors found that cereals comprise 22 per cent of the total food of a large number of families in this country furnishing 31 per cent of the protein 7 per cent of the fat, and 55 per cent of the total carbohydrates They have separated the large number of cereal breakfast foods which are on the market into three groups

1 Those prepared simply by grinding the grain

2 Those which have been steamed or otherwise partially cooked, and then ground or rolled

3 Those which have been acted upon by malt which induces chemical changes in the starch

Cooking Cereals —The proper cooking of cereals is of more importance than the relative proportions of nutriment they contain While definite statements cannot be made regarding the length of time which different cereals should be boiled all of them require prolonged cooking They are much more likely to be undercooked than overcooked With undercooked foods starch grains may appear in the feces due to the coverings of the granules which are impermeable to the digestive juices In general the more abundant and the tougher the fiber the longer should the process of cooking be continued For example, whole grains require more cooking than crushed grains Rice contains but little fiber and may be thoroughly cooked in a relatively short time

According to Woods and Snyder it is difficult to know in the case of partially cooked breakfast foods how much of the necessary cooking has been done in the factory They point out that overcooking is harmless and suggest that further cooking in the home is usually desirable

Examinations of malted breakfast cereals carried out at the Iowa Experiment Station showed that the largest amount of soluble carbohydrate present was 13 per cent of the total carbohydrates the lowest, 0 15 per cent The average was around per cent At the Michigan Station it was found that the largest proportion of the soluble carbohydrates in these preparations consists of dextrin Woods and Snyder state that "the claims made for some brands that the carbohydrates are completely or largely predigested are quite unwarranted"

DIGESTIBILITY OF FOODS[*]

General Considerations.—The term "digestibility" may be understood to mean either the ease and rapidity with which a food is digested, or the completeness of its digestion. This distinction is not always made, however, and confusion has often arisen in the interpretation of the results obtained by different observers. Likewise, when the opinions of physicians and physiologists are not in agreement, the fact is often overlooked that the conditions under which the observations are made are different. Physicians deal with those who are ill, physiologists with *those who are well. The term "digestibility" is probably understood by* most physicians to mean ease of digestion, by most physiologists completeness of digestion. If these different points of view are borne in mind, discordant opinions may frequently be reconciled.

Foods leave the stomach in the order in which they are digested and liquefied. The length of time they remain in the stomach has been taken by some authors as the measure of their digestibility. While the length of its sojourn in the stomach may not affect the thoroughness with which a food is ultimately digested, it may have an important influence *upon subsequent feedings, especially if these be given at short intervals.* Delay in gastric digestion often produces in healthy persons unusual or uncomfortable sensations referable to the stomach. In persons who are ill, delay of gastric digestion may not only interfere with the frequency of the feedings but may cause loss of appetite, nausea, and even the rejection of food.

The nutritive values of foods cannot always be measured by the amounts of the different foodstuffs they contain. They depend rather upon the extent to which these foodstuffs may be digested and absorbed. *While it is generally believed that the greater part of most foods is* digested and absorbed by healthy men, our knowledge of the extent to which they are utilized by persons who are ill is far from complete.

A number of factors affect the digestion and utilization of foods. Some of the more important of them may be considered.

The favorable influence of appetite upon digestion has been known so long that it is best expressed in the form of the adage, "Hunger is the best sauce." It was only about twenty years ago, however, that Pavlov established the popular belief upon a scientific basis through his discovery that the desire for food induces a reflex stimulation of gastric juice. Pavlov calls this secretion the "appetite" or "igniting juice." Its function is to initiate the digestive process, which then proceeds more or less automatically through the stimulating action of the products of

[*] In the preparation of this section the author has derived much information from U S Dept of Agriculture Bull No 85 and Farmers Bulls Nos. 85 [illegible]

digestion upon the gastric glands Food eaten without appetite may lie in the stomach unchanged for hours Physicians have made use of this knowledge for many years, and have striven to arouse an appetite in patients when it was lacking Another and related, adage, "Laugh and grow fat,' finds application here Meals eaten amid cheerful surroundings and in pleasant company are taken with greater zest and enjoyment, and are more easily digested

The ease and completeness of digestion also depend in general upon the amount of food which is eaten at a time the greater the quantity the less rapidly and probably less thoroughly, is it digested Overeating is a common cause of digestive disorders The custom of taking three meals a day is based upon the general experience of mankind that the amount of food required can be handled with less tax upon the digestive organs when distributed in this manner

Careful regulation of the quantity of food allowed at one time is of even more importance when persons are ill or have weak digestions The common practice of giving small quantities of food at frequent intervals to persons with enfeebled powers of digestion is supported by the experiments of Pavlov who found that if food was given to a dog in small quantities at intervals the gastric juice was stronger than if the whole ration had been given at once Moreover the appetite of an invalid is often impaired by even the sight of large portions' of food

Experiments upon healthy men have repeatedly shown that a well balanced dietary is digested more thoroughly than a single food The significance of such observations with respect to the arrangement of dietaries for invalids, is apparent

The secretion of gastric juice is intimately related to the quantity of water in the body (Pavlov) Water is drawn from the blood by the cells of the gastric glands as they elaborate the secretion If the supply of water is not sufficient the digestive juices are deficient in quantity and digestion is impaired Therefore water should be supplied to the body by enemata or otherwise as an aid to digestion in diseases attended by its loss in large quantities, such as excessive vomiting, profuse diarrhea, and hemorrhage Every food determines a certain amount of digestive work and when a given dietary is long-continued, definite and fixed types of gland activity are set up which can be altered but slowly and with difficulty In consequence digestive disturbances are often instituted if a change be made suddenly from one dietary regime to another especially from a sparse to a rich diet (Pavlov) It should be added that patients cannot all be fed alike, even when suffering from the same disease Prejudices and idiosyncrasies to foods are not removed by illness and must be recognized Variety in food is sought in health and should be permitted in disease to the extent which is compatible with the patient's well being

Digestibility of Meats—Numerous observations concerning the digestibility of meats have been made upon healthy men Valuable data have also been obtained by Pavlov and his coworkers from their experiments upon dogs But we possess very little information respecting the digestibility of meats in various diseases The conclusions drawn from experiments upon healthy men refer particularly to the thoroughness of digestion They should not be applied without caution to persons who are ill, and who, on that account, may digest meat slowly and with difficulty

Probably the most important conditions affecting both the rate and completeness of digestion of meat are the amount of connective tissue and fat it contains, and the method and duration of the cooking

The "appetite" juice plays a less important role in the digestion of meat than in the digestion of eggs and bread This is due to the presence of extractives in meat, which are direct excitants of the gastric glands *According to Pavlov, the secretion of "meat juice" is the most rapid of all* Raw meat introduced unnoticed into the stomach of a dog excites secretion within from 15 to 30 minutes But if meat be freed from extractives by prolonged boiling and the water be forced from it by compression it has no stimulating effect upon the gastric glands

The influence of the connective tissue upon the digestion of meat is mainly mechanical, though the mastication of tough, fibrous meat is not attended with pleasure The presence of much connective tissue prevents free access of the digestive juices to the muscle fiber, and affects both the rapidity and completeness of digestion The practice of pounding meat across the cut ends has for its object the separation of the muscle fibers from the connective tissue Likewise the prolonged cooking of meat converts the connective tissue into gelatin, and frees the muscle fibers, though they are probably rendered slightly less digestible by the process

Influence of Fat Content Digestion of Meat—Meats vary in the amount of fat they contain Dried meat may not have more than 3 per cent of fat, while pork may contain as much as 50 per cent The presence of fat inhibits the secretion of gastric juice, and prolongs the stay of both protein and carbohydrate in the stomach Therefore, the rapidity of the digestion of meat bears a direct relation to the amount of fat it contains Fat meats such as pork, are well known to be difficult of digestion

While but little attention has been devoted to the percentages of the different meats which are absorbed, it is probable that meat of all kinds, whether raw or cooked, is very completely absorbed by healthy men—nearly all of the protein and about 95 per cent of the fat

Our knowledge of the digestibility of meat in disease is confined largely to the results of clinical observation While carefully made ob-

servations of this kind have a definite value, it is desirable that they should be confirmed by experiment Yet, one of the conspicuous features of Pavlov's work is the frequency with which he has confirmed both popular and clinical beliefs respecting digestion

In giving meat to invalids every precaution should be taken which will make for rapidity of digestion It should be served attractively and in not too large portions in order to promote the secretion of the "appetite" juice If given raw it should be finely scraped, as this separates the fibers from the connective tissue Raw meat should not be forced upon a patient, since it is not certain that raw meat is more quickly digested than slightly cooked meat If cooked too long the muscle fibers become hard, tasteless to many persons, and difficult to digest Furthermore meats which contain relatively little fat should be selected for invalids

Poultry is popularly supposed to be more easily digested than red meats As no experiments contradict this belief, it may provisionally be accepted If true it is probably due to the tenderness of the fiber and the relatively small proportion of fat The fatter kinds of poultry are less easily digested than the lean The popular belief that the light meat is more digestible than the dark may be due to the higher proportion of fat in the dark meat but the difference is slight

Attention should be directed here to the fact that the extractive-content is essentially the same in white and red meats In diseases where it is desirable to reduce the purin bodies to a minimum there is no advantage in prohibiting red meats if the patient is allowed to eat poultry at will It is probably true so far as the sick are concerned that the only difference between white and red meats concerns ease of digestion

Digestibility of Fish—The relative digestibility of different fish appears to be dependent upon the amount of fat they contain. Langworthy has grouped the commoner fish from this standpoint, into three classes

1 Fish containing over 5 per cent of fat salmon, shad, herring Spanish mackerel, and butterfish

2 Fish containing between 2 per cent and 5 per cent of fat whitefish, mackerel mullet, halibut, and porgy

3 Fish containing less than 2 per cent of fat smelt black bass, bluefish, white perch, weakfish brook trout, hake flounder, yellow perch, pike pickerel, sea bass, cod, haddock.

Digestibility of Eggs—Most of the experiments upon the digestibility of eggs have been made upon healthy men and lower animals All of them indicate that eggs are easily and thoroughly digested Rubner found that with a diet consisting of hard boiled eggs alone the nitrogen was absorbed to about the same extent as that of meat while the fat was absorbed better than the fat of meat. Aufrecht and Simon studied the absorption of lightly boiled and raw eggs, compared with meat, as part

of a mixed diet, and found that the absorption of both the nitrogen and fat was greater in the egg—than in the meat—period They concluded that lightly boiled and raw eggs have a higher food value as part of a mixed diet than a corresponding amount of meat

The method of cooking eggs appears to affect the rate rather than the completeness of their digestion While this has no appreciable effect in health, it may cause disorders of digestion in disease Judged by the length of time they remain in the stomach, eggs are digested in the following order (*the most easily digested are given first*) *lightly cooked* eggs, raw eggs, buttered eggs, hard boiled eggs, omelette Judged by the completeness of absorption, Aufrecht and Simon have shown that lightly boiled eggs have a somewhat lower nutritive value than raw eggs Jorissenne believes that if hard boiled eggs are thoroughly masticated they are digested as easily as lightly cooked eggs Very few experiments have been made upon the relative digestibility of the white and the yolk of the egg Stern found that raw or half raw yolk is readily digested, and Rose and Macleod have found that there is very little difference in the digestibility of raw or cooked whites of eggs

While it is probable that the facts regarding the digestibility of eggs by healthy men apply equally to those who are ill, positive statements to this effect cannot be made Probably the most important factor influencing the digestibility of eggs in disease is whether they are taken with relish White of egg eaten without appetite will lie in the stomach unchanged for a considerable time (Pavlov) This is due to the fact that the egg contains no substances like the extractives of meat which are capable of exciting the flow of gastric juice Once the flow is started, the products of digestion stimulate further secretion If water be taken with egg albumin it initiates the secretion (Pavlov) A similar result is obtained if the egg is preceded by, or given with, meat broth The difference in digestibility between lightly cooked and raw eggs is so slight that it is not necessary to compel patients to take them raw When a patient's digestive powers are much enfeebled, eggs should not be buttered, but there is no objection to the addition of salt and pepper Fraser found in experiments upon the artificial digestion of eggs that tea, coffee, and cocoa retarded digestion of the protein, though the effect of coffee was less marked than that of the others

Idiosyncrasy to Eggs—Persons are seen occasionally who have an idiosyncrasy against eggs The peculiarity is usually discovered early in life The symptoms develop after eating egg even in small quantities and irrespective of whether it is taken alone or combined with other foods, as in custards The symptoms are often severe, collapse may occur Urticaria is common

The Digestibility of Milk—The following account of the digestibility of milk is taken principally from Pavlov There are three properties of

milk which secure it an exceptional position Milk, when compared with other foods in nitrogen equivalents, requires the weakest gastric juice and the smallest quantity of pancreatic fluid Consequently, the secretory activity necessary for its assimilation is much less than for any other food When milk is introduced mechanically into the stomach of an animal, it causes a secretion both from the stomach glands and also from the pancreas, consequently it appears to be an independent chemical excitant of the digestive canal and in this action there is no essential difference whether the milk be introduced directly into the stomach or be given the animal to lap Milk excites not only a really effective but also a very economic secretion and the appetite is unable to stimulate this secretion into a more active or abundant flow The price which the organism pays in digestive work for the nitrogen of milk is much less than for other foods

Idiosyncrasy to Milk —In rare instances persons exhibit an idiosyncrasy against milk Halberstadt considers this to be evidence of a congenital constitutional anomaly The idiosyncrasy may be against the albumin fat, or whey In some cases the deleterious effects of milk are thought to be due to a change it causes in the flora of the intestine Definite poisoning occurs in these cases often accompanied by inflammatory changes in the alimentary tract and must be differentiated from the digestive disturbances which many physicians claim are always caused by milk Tugendreich has described a similar poisoning under the title of Buttermilk Fever '

Digestibility of the Carbohydrates —The digestibility of the carbohydrates depends in general upon the relative proportions of starch (or sugar) and cellulose The greater the amount of cellulose and the thicker the cell walls the less digestible is the food The preparation of certain foods, such as the milling of grain has for its object the removal of the greater portion of the cellulose Sugars may be regarded as partially digested carbohydrates Except when taken in quantities and in mixtures which interfere with the normal processes they are easily digested and completely absorbed Carbohydrates leave the stomach quickly

Bread and cereals may be taken as types of the carbohydrate foods

Digestibility of Bread —Bread is generally considered to be an easily digested food, but the appetite juice is necessary for its perfect digestion Bread eaten without appetite may lie in the stomach for a long time without change Bread is digested chiefly by the pancreatic secretion The lactic acid which is formed in the stomach stimulates the pancreas and thus aids the digestion

The majority of the experiments on the digestibility of bread relate to the completeness of its digestion by healthy men. Meyer and Voit, experimenting with different kinds of wheat and rye bread found that the digestibility of bread depended chiefly upon its lightness. Studies car

ried out at the Minnesota Experiment Station upon the digestibility of breads made from graham whole wheat and standard patent flours demonstrated that bread made from standard patent flour was most completely digested, whole wheat bread next, and graham least. The digestibility of crackers, macaroni, and various sweet cakes made from white flour was found at the same Station to be essentially the same as that of bread.

There is a popular belief that cold bread is more easily digested than hot bread. This is probably true but it is due to the physical condition of the bread and not to the heat. Hot bread is moist, and if not soggy before being eaten is compressed into tough masses during mastication, and thereby rendered less *easily* digestible. If properly made, cold or stale bread contains less moisture and is not open to the same objection in that it does not form these tough masses during mastication.

As far as is known the above facts are applicable in disease. Du Bois found that bread and crackers are easily and completely digested by typhoid fever patient.

When bread and similar foods are eaten by persons who have little or no appetite they should be combined with substances which have a local stimulating action upon the gastric glands. Water is sufficient for the purpose but meat broth is often to be preferred.

Digestibility of Cereal Breakfast Foods.—The digestibility of cereal breakfast foods has been investigated at the Connecticut, Maine, and Minnesota Experiment Stations. The results showed that in healthy men the cereal breakfast foods in general are somewhat less digestible than white bread. It was found at the Michigan Experiment Station that the greater part of the soluble carbohydrates in the so-called predigested breakfast foods consists of dextrin.

Digestibility of Fat.—Fat illustrates especially well the distinction which must be made between ease and completeness of digestion. All healthy persons consume daily larger or smaller quantities of fat in the form of butter cream or the native fats contained in other foods. But an excess of fat over the usual quantity or a change in its form is distasteful to many persons, difficult to digest (as regards the stomach digestion), and may produce nausea. Nevertheless, if it is tolerated by the stomach, only a small portion of the fat ingested escapes absorption in health.

Fat is not digested in the stomach but may have an important influence on gastric digestion. Fat exerts an inhibitory action upon both the psychic or "appetite" and local gastric juices, and delays the passage of the chyme into the duodenum (Pavlov). The inhibitory action of fat affects especially the digestion of protein, and explains the well known fact that fatty protein foods are difficult to digest, whether the fat be native to the food or be added to it in the process of cooking. On the

other hand, the addition of fat to starchy foods, for example, bread and butter, is customary, and according to Pavlov, rational. Bread requires little gastric juice for its digestion; the fat restrains the activity of the gastric glands, while at the same time it promotes the secretion of pancreatic juice, which is needed for the digestion of the starch, the partially digested protein, and the fat itself. Though an excess of fat in a mixed meal may cause disturbances of digestion, fat alone, even when taken in relatively large quantities, is not difficult to digest.

Large amounts of fat may cause regurgitation of the duodenal contents into the stomach. This fact has been observed both experimentally and clinically (Passler).

Ordinarily, fat is well absorbed in health. Its absorption appears to be related in a measure to its melting point. Butter, with a melting point of 37° C., is more completely absorbed than mutton fat with a melting point of 52° C. When the food contains 80 to 100 grams of fat only 4 to 6 per cent is lost normally in the feces.

The absorption of fat varies greatly, however, in disease. According to Umber, 45 per cent of ingested fat may be lost in the feces when the bile duct is occluded. Thus in obstructive jaundice fat absorption may be interfered with. In disease of the pancreas the loss may reach 7[illegible] per cent. On the other hand, the absorption of fat in typhoid fever is often remarkable. Some of my patients studied by Du Bois, when taking 200 grams of fat a day in the form of cream and butter, lost an average of 7.2 per cent in the feces in the steep-curved period, and in convalescence, while taking similar amounts, they lost 4.5 per cent.

Length of Time Food Remains in Stomach.—The length of time which a food remains in the stomach has often been accepted as the measure of its digestibility, but is probably only an indication of the ease of its digestion.

The length of time which certain foods remain in the stomach is shown in the following table of experiments by Penzoldt.

ONE TO TWO HOURS

Grams	*Kind of Food*
100-200	Water
200	Charged water
200	Tea (without admixture)
200	Coffee (without admixture)
200	Cocoa (without admixture)
200	Beer
200	Light wine
100-200	Boiled milk
200	Meat broth
200	Peptone in water
100	Soft boiled egg

Two to Three Hours

Grams	*Kind of Food*
200	Coffee with cream
200	Cocoa with milk
200	Malaga wine
300–500	Water
300–500	Beer
300–500	Boiled milk
100	Raw, scrambled, hard boiled egg and omelette
250	Calf's brain, boiled
12	Raw oysters
200	Boiled carp
200	Boiled pike
200	Boiled haddock
200	Dried codfish
150	Boiled cauliflower
150	Cauliflower salad
150	Boiled asparagus
150	Potato
150	Potato soup
150	Cherry preserves
150	Raw cherries
70	White bread, fresh or old, dry or with tea
70	Cracknel
50	Albert biscuits

Three to Four Hours

Grams	*Kind of Food*
230	Boiled young fowl
250	Roast partridge
270–280	Boiled pigeon
195	Roast partridge
250	Beef, raw or cooked
250	Boiled calf's foot
160	Ham, raw or cooked
100	Roast veal, warm or cold
100	Broiled beefsteak, cold or warm
100	Scraped raw beefsteak
100	Tenderloin
200	Rheinsalmon, boiled
72	Caviar
150	Rye bread
150	Graham bread
100–150	Albert biscuit
150	Boiled rice
150	Boiled cabbage
150	Boiled carrot
150	Spinach
150	Raw radish
150	Apple

FOUR TO FIVE HOURS

Grams	*Kind of Food*
210	Roast pigeon
250	Broiled filet of beef
2[illegible]0	Broiled steak
250	Smoked tongue
100	Smoked meat
250	Roast hare
240	Roast partridge
250	Roast goose
2[illegible]0	Roast duck
200	Salt herring
1[illegible]0	Lentil soup
200	Pea soup

COEFFICIENTS OF DIGESTIBILITY (ABSORBABILITY) IN DIFFERENT GROUPS OF FOOD MATERIALS*

Kind of Food	Per Cent Protein	Per Cent Fat	Per Cent Carbohydrate
Meats and fish	97.0	95.0	
Eggs	97.0	95.0	
Dairy products	97.0	95.0	98.0
Animal food (of mixed diet)	97.0	95.0	98.0
Cereals	85.0	90.0	98.0
Legumes (dried)	78.0	90.0	97.0
Sugars			98.0
Starches			98.0
Vegetables	83.0	90.0	95.0
Fruits	85.0	90.0	90.0
Vegetable foods (of mixed diet)	84.0	90.0	97.0
Total food (of mixed diet)	92.0	95.0	97.0

* From U. S. Dept. of Agriculture Farmers' Bull. No. 14[illegible]

EFFECTS OF STARVATION

It will be necessary to distinguish between the effects of complete and of partial deprivation of food. Starvation is complete when a person receives no food and the energy necessary for the continuance of life is derived from his own body. Partial starvation occurs when a person receives only a portion of the food he requires. Under such circumstances the tissues of the body are drawn upon for only part of the necessary energy. In actual practice, however, the physician must take into consideration the possible disturbances of metabolism produced by the disease from which the patient is suffering and which also may be a cause of the starvation.

Effects of Complete Starvation.—Complete abstinence from food for short periods is not—or at least is not likely to be—harmful in the case of adult. Nature provides for such emergencies by accumulating reserves

of glycogen and fat Young children, on the other hand do not bear starvation well even for short periods The reserve supply of glycogen is relatively small, and is soon exhausted After its exhaustion, the body derives all of its energy from protein and fat Fat, which is of lesser importance is sacrificed in favor of protein The heavy demand made upon the fat results in its incomplete combustion and the occurrence of acidosis with acetone bodies in the blood and urine

The expenditure of energy by the body remains normal for the first day or two of complete starvation Rubner reckons it at from 30 to 32 calories per kilogram of body weight When the subject is at *absolute rest* however the heat production may fall to 22 to 26 calories per kilogram (Atwater Tigerstedt, Magnus Levy) These figures represent the minimal metabolism compatible with life, and cannot be applied in practice, because patients are rarely or never at complete rest, unless they are asleep or in coma

Loss of weight is characteristic of starvation It is due to the consumption of the body tissues and to the elimination of water and salts As the weight diminishes the expenditure of energy falls the fall according to Rubner corresponding to the loss in weight *The body temperature remains practically constant* The urine is diminished in amount The loss of nitrogen is large for the first day or so, after which it remains fairly constant (10 to 1 grams) for a week or ten days Material divergence from these figures indicates the influence of disease However, in long fasts factors other than the simple sparing of the direct effect of food come into play

Benedict has shown that recovery from starvation is rapid in health and may be followed by an actual gain in weight Fasting for short periods appears to stimulate the body to increase its store of fat This is regarded by Benedict to be a protective mechanism

Effects of Partial Starvation —Partial starvation may occur through force of circumstances such as poverty or as the result of disease In the latter case it is not always easy to distinguish between the influence of insufficient food and that of the disease From the medical standpoint partial starvation probably occurs with greatest frequency in prolonged febrile and in malignant diseases

The body is capable of regulating its expenditure of energy to some extent When the food supply is insufficient the production of energy falls correspondingly But von Noorden believes that the minimal amount of energy required by persons who are bedridden, or who remain indoors and do but little work amounts to from 30 to 32 calories per kilogram Their diets should be arranged upon this basis Persons who are underfed economize their protein at the expense of the less important fat The longer the deprivation of food continues the smaller the relative amount of protein consumed

It should be added that persons who are undernourished are less able to resist invasion by bacteria and to combat infection

EFFECTS OF OVERFEEDING

A person is overfed when he takes and absorbs more food than is required for his energy exchange If an excess of food is not digested and absorbed, it is likely to cause alimentary disturbances

The effects of overfeeding may be either physiological or pathological that is, the general condition of the person may be improved or various disturbances of function may be brought about We are concerned here chiefly with the physiological effects of overfeeding

A person who is overfed gains in weight largely through the deposition of fat, though there may be a coincident retention of nitrogen Fat is a relatively inactive tissue from the metabolic standpoint The accumulation of fat adds to the reserves but does not increase the power of the body Improvement in tone if not growth of muscle is necessary to bring the body into a state of vigorous health This depends to a great extent upon proper exercise and should be borne in mind when one is employing the overfeeding cure

The objects to be sought in overfeeding may be either the accumulation of fat, or improvement in the condition of the muscles, or both In arranging the diet the effects of the different foodstuffs must be taken into consideration Fat is the best food for simple fattening purposes because foreign fats are deposited in the body without change and with the expenditure of very little energy Carbohydrate ranks next to fat in value It has been estimated that one fourth of the potential energy of carbohydrate is lost before it is deposited as fat Protein is least valuable because of the increase it causes in metabolism and because it cannot add materially to the store of fat Therefore, an increase in protein alone is irrational in overfeeding cures Van Noorden advises specifically against the employment of proprietary protein foods for such purposes Even in convalescence from infective diseases an increase of protein does not materially affect the retention of nitrogen

While the experiments of both Krug and Dapper indicate that an increase in the carbohydrate ration and a relatively greater increase of fat are accompanied by a retention of nitrogen in lower animals this fact has not yet been established for man except in typhoid fever Typhoid fever patients may retain nitrogen during the course of the disease and in convalescence when the diet furnishes an excess of both carbohydrate and fat (Shaffer and Coleman)

General clinical experience appears to indicate that the most suitable diet for an overfeeding cure is rich in both fat and carbohydrate The

of glycogen and fat. Young children, on the other hand, do not bear starvation well even for short periods. The reserve supply of glycogen is relatively small, and is soon exhausted. After its exhaustion, the body derives all of its energy from protein and fat. Fat, which is of lesser importance, is sacrificed in favor of protein. The heavy demand made upon the fat results in its incomplete combustion and the occurrence of acidosis with acetone bodies in the blood and urine.

The expenditure of energy by the body remains normal for the first day or two of complete starvation. Rubner reckons it at from 30 to 32 calories per kilogram of body weight. When the subject is at *absolute rest*, however, the heat production may fall to 22 to 26 calories per kilogram (Atwater, Tigerstedt, Magnus Levy). These figures represent the minimal metabolism compatible with life, and cannot be applied in practice because patients are rarely or never at complete rest, unless they are asleep or in coma.

Loss of weight is characteristic of starvation. It is due to the consumption of the body tissues and to the elimination of water and salts. As the weight diminishes, the expenditure of energy falls, the fall, according *to Rubner, corresponding to the loss in weight. The body temperature* remains practically constant. The urine is diminished in amount. The loss of nitrogen is large for the first day or so, after which it remains fairly constant (10 to 13 grams) for a week or ten days. Material divergence from these figures indicates the influence of disease. However, in long fasts factors other than the simple sparing of the direct effect of food come into play.

Benedict has shown that recovery from starvation is rapid in health and may be followed by an actual gain in weight. Fasting for short periods appears to stimulate the body to increase its store of fat. This is regarded by Benedict to be a protective mechanism.

Effects of Partial Starvation.—Partial starvation may occur through force of circumstances, such as poverty, or as the result of disease. In the latter case it is not always easy to distinguish between the influence of insufficient food and that of the disease. From the medical standpoint partial starvation probably occurs with greatest frequency in prolonged febrile and in malignant diseases.

The body is capable of regulating its expenditure of energy to some extent. When the food supply is insufficient the production of energy falls correspondingly. But von Noorden believes that the minimal amount of energy required by persons who are bedridden or who remain indoors and do but little work amounts to from 30 to 32 calories per kilogram. Their diets should be arranged upon this basis. Persons who are underfed economize their protein at the expense of the less important fat. The longer the deprivation of food continues the smaller the relative amount of protein consumed.

of the urine rose at once Therefore since but little protein is absorbed and since proteins are readily decomposed by the intestinal flora, giving rise to substances which may irritate the bowel, it appears to be undesirable to give nutrient enemata containing protein even in its partially digested forms

There is a difference of opinion regarding the absorption of fat Brown was unable to prove the absorption of emulsified and pancreatized fats when given by rectum to a patient suffering from chyluria though when fat was taken by mouth the amount in the urine was promptly increased Boyd, on the other hand has shown that fat may be absorbed though he calls attention to the wide differences in the absorptive power of different individuals Boyd recommends yolk of egg and emulsified olive oil as suitable fats for nutrient enemata Cream has also been used

Dextrose is readily absorbed by the large intestine, and is probably the best form in which to give carbohydrate Dextrin has also been recommended Brugsch states that dextrinized or malted starch is less irritating than the sugars and may be employed instead of them. Brown was able to raise the respiratory quotient by the use of dextrose and to cause the diminution or disappearance of acidosis Dextrose may irritate the bowel and cause cramplike pains when given in concentration greater than 10 per cent I have found it necessary at times to reduce the strength of the solution to 7 per cent and even to 5 per cent If sugar is absorbed by the inferior hemorrhoidal veins it enters the general circulation without passing through the liver and may cause glycosuria

Salts and water are readily absorbed by the colon and there is little doubt that much of the benefit which has been ascribed to nutrient enemata was attributable to these substances Alcohol, likewise, is readily absorbed, and is often added in small quantities to enemata

Method of Giving Nutrient Enemata — A cleansing enema of normal salt solution (0 9 per cent) should be given every morning one hour before the nutrient enema Some authors recommend a cleansing enema before each nutrient enema but unless the nutrient enema contains foods which are not readily absorbed this procedure scarcely seems necessary and may increase the irritability of the colon The patient should be placed either upon the left side or the back with the hips elevated on a pillow The apparatus may consist of a medium size funnel inserted into the end of a small rectal tube or large catheter or an inverted thermos bottle connected with the rectal tube or catheter by means of rubber tubing A small metal tube passed through the stopper and reaching to the bottom of the bottle permits the entrance of air and the flow of its contents A bulb-syringe is not suitable because of the difficulty of controlling the pressure, and the likelihood of injecting air The funnel-apparatus is perhaps more convenient for thicker enemata, the bottle for the sugar solu

Voit or Atwater standard should be followed in determining the amount of protein In all cases the total energy requirement of the patient should be calculated and the diet arranged to furnish more energy than the calculation calls for

While the pathological effects of overfeeding cannot be considered at length, attention should be called to the fact that injudicious overfeeding may cause pathological obesity

METHODS OF ARTIFICIAL FEEDING

When for any reason patients cannot or will not take food by mouth, other methods of nourishing them must be employed

Rectal Feeding—Rectal feeding may be resorted to when swallowing is difficult or impossible as in cases of tumor or stricture of the throat or esophagus when the muscles of deglutition are paralyzed, in cases of ulcer or tumor of the stomach, and in cases of uncontrollable vomiting When for any reason patients are incapable of taking all the food they require by mouth, additional food may be given for brief periods per rectum

The nutritive value of nutrient enemata has, according to recent investigations, been greatly overestimated, and the physician should keep clearly in mind the fact, when employing this method of alimentation, that the patient is receiving only a portion of the food he requires Patients have subsisted upon nutrient enemata for several weeks, but it has been largely at the expense of the body tissues The gains in weight which have occurred, especially after severe hemorrhages have been shown to be due to retention of water Probably the greatest quantity of food which a patient is capable of absorbing by rectum reaches only from one-fourth to one-third of the total daily requirement, even when at rest in bed Boyd calls attention particularly to the fact that the amount of food absorbed depends upon the patient's capacity for absorption and not upon the quantity of food injected Therefore, it is not always desirable to give large enemata, the unused portion is likely to decompose and cause irritation

Nutrient enemata do not enter the ileum, and such absorption as occurs must be from the colon Nor do nutrient enemata cause a reflex secretion of gastric juice (Pavlov)

The different foodstuffs are not absorbed with equal facility by the colon All of the available evidence indicates that protein is poorly absorbed Brown compared the nitrogen output in the urine from saline and nutrient enemata, and observed not only that the curves were similar, but that they were comparable to the nitrogen excretion of healthy fasting men When the same amount of food was given by mouth the nitrogen

in such cases oftener than once or twice a day. In the case of persons who are conscious, food may be given three times a day.

Only liquid foods are suitable for gavage. The "meal" should be made up (as to bulk and energy value) according to the frequency with which it is to be repeated, and should be warmed to about the body temperature. Milk, cream, eggs, and sugars are best adapted to the method and may be employed in the following or similar mixtures:

MIXTURE USED FOR GAVAGE

Food	Quantity	Calories
Milk	1 pint (500 c.c.)	350
Cream	1 pint (500 c.c.)	1000
Lactose or cane sugar	50 grams	200
		1550
Milk	1 pint (500 c.c.)	350
Cream	½ pint (250 c.c.)	500
Eggs	2	160
		1010

Subcutaneous Feeding—*Fat.* Leube first suggested the subcutaneous administration of oils and fats as a means of supplying the body with nutriment. Mills has recently made an extended study of the method in Lusk's laboratory, and the following statements are based upon his results.

Fats which are similar in composition to that of the body are most readily absorbed. Emulsions are absorbed better than plain oils. The best emulsion is made with from ... to ... per cent of egg lecithin and sterile water. The site of the injection should be sterilized with tincture of iodin and should be massaged gently afterward. Care should be taken to avoid entering a vein, as cerebral or pulmonary fat embolism would result. If the emulsion is injected slowly into the subcutaneous tissue, 60 grams of oil may be given at one time without causing discomfort. Mills has proved that fats introduced subcutaneously may be burned directly, thus sparing the body fat, may be retained in the body in their own form, or may be reconstructed into body fat.

The subcutaneous administration of fat should not be employed unless the patient is capable of taking food by mouth. While the method holds promise of being useful, it has not been perfected sufficiently to permit of its recommendation for general purposes.

Protein and Sugar.—While numerous attempts have been made to administer proteins and sugar subcutaneously, the methods hitherto employed have not proved practical. Native protein solutions are difficult

FORMULÆ FOR NUTRIENT ENEMATA

Nutrient	Weight	Calories
Dextrose	20–30 grams	80–120
Water	200–300 c.c.	
Dextrose	20–30 grams	80–120
Wine (white or red)	15–30 c.c.	10–20
Water	200–300 c.c.	
Boas recommends		
Milk	200 c.c.	175
Yolk of egg	2	100
Salt	A pinch	
Wine	15 c.c.	10
Flour	15 grams	56
Myer recommends		
Cream	250 c.c.	500
Peptone	2 grams	8
Pancreatin	5 grams	

tion. The rectal tube should be oiled, freed of air by allowing the enema to fill it, and introduced well into the intestine.

The size of nutrient enemata varies from 6 to 10 ounces (200 to 300 c.c.), the larger the enema the less frequent the need of repetition. They should be given at temperatures of 95° to 100° F. Nutrient enemata should always be injected slowly. The flow may be regulated by raising or lowering the container. The sugar solutions are often given drop by drop, after the Murphy method. It is rarely advisable to give more than three enemata a day.

The patient should be instructed to remain quiet afterward and to resist expulsion of the enema. Pressure upon the perineum with a folded towel by the attendant will often enable the patient to retain it when otherwise it would be rejected. When the colon becomes irritated 10 to 20 *drops of laudanum may be added to the enema in order to quiet the* nervous reflexes set up by the irritation.

Gavage.—The term "gavage" designates forced feeding through an esophageal tube. The tube may be passed through the mouth or the nose. Gavage is especially indicated in the case of hysterical or psychopathic patients who refuse food. It has also been employed in stricture of the esophagus, whether spasmodic or organic, in paralysis of the muscles of deglutition, and in comas. The practice of gavage is not unattended by danger, since the tube may enter the larynx, especially when the patient is unconscious, and cause pneumonia. Food should not be administered

value of the food should not be permitted to fall below, nor to greatly exceed, the daily requirement of the patient

In addition to its employment in nephritis the salt poor diet has been recommended for the edema of chronic cardiac valvular disease, for the ascites of cirrhosis of the liver, pleurisy with effusion, arterial sclerosis, and diabetes insipidus

SALT CONTENT OF FOODS

According to Iera

Food	Per Cent Sodium Chloride Raw Material
Meats	
Mutton	0.1[illegible]
Veal	0.13
Calf's brain	0.[illegible]0
Calf's kidney	0.3[illegible]
Calf's liver	0.14
Beef (lean)	0.11
Pork (lean)	0.10
Venison	0.11
Fish	
Trout	0.1[illegible]
Halibut	0.[illegible]0
Herring	0.2
Cod	0.16
Carp	0.086
Salmon	0.081
Mackerel	0.[illegible]8
Haddock	0.39
Oyster (washed)	0.5[illegible]
Oyster (with sea water)	1.14
Poultry	
Duck	0.14
Goose	0.[illegible]0
Chicken	0.14
Pigeon	0.1[illegible]
Turkey	0.17
Smoked and Salted Foods	
Ham (raw)	4.15—5.[illegible]
Ham (boiled)	1.[illegible]—[illegible]
Salmon (smoked)	[illegible].[illegible]0
Bacon (smoked, German)	1.01
Bacon (smoked, American)	11.[illegible]
Corn beef, German	[illegible].04
Corn beef, American	11.[illegible]
Cod (salt) *	[illegible]3.00
Cod (salt, boneless) *	19.00
Herring (smoked) *	11.[illegible]0

Food	Per Cent Sodium Chloride Raw Material
Smoked and Salted Foods—Cont	
Mackerel (salt, dressed)	10.40
Salmon (smoked, salted)	10.8[illegible]
Sardines (French, in oil)	1.34
Cod liver oil	0.17
Gelatin (dry)	0.[illegible]
Beef marrow	0.11
Sausages, Frankfurter	2.[illegible]0
Sausages, various kinds	2.90—8.10
Anchovy paste (Cross & Blackwell)	40.1
Meat Extracts	
Liebig's	2.60
Kemmerich	1.40
Various bouillon capsules, extract, etc	9.40—[illegible]0
Prepared Foods	
Plasmon	0.21
Roborat	0.00[illegible]1
Sanatogen	0.4[illegible]
Somatose	0.[illegible]6
Bovril's preparations	0.26—14.1
Valentine's Meat Juice	0.0[illegible]—1.20
Egg (white and yolk)	0.[illegible]1
Egg (white alone)	0.31
Egg (yolk alone)	0.033
Caviar	3.00
Milk (whole)	0.16
Cream	0.13
Buttermilk	0.16
Whey	0.11—0.15
Condensed Milk	0.40
Butter (unsalted)	0.0[illegible]—0.[illegible]1
Butter (salted)	1.00—3.00
Peanut butter *	4.10
Oleomargarine	[illegible].1[illegible]
Palmin	0.0016
Fructin	0.10

* Analyses from Atwater and Bryant.

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THE SALT POOR DIET

The diet of civilized man contains ordinarily from 10 to 15 grams of common salt This amount is readily excreted by normal kidneys in twenty four hours In some cases of nephritis, however, especially those of the parenchymatous type the kidneys are unable to excrete more than 2 or 4 grams or even less of salt a day The salt which is retained passes into the tissue fluids and causes, or increases an existing edema The inability of the kidneys to excrete salt sometimes runs parallel with an inability to excrete water

The excretory power of the kidneys for salt may be tested by a diet of 3 liters of milk (this contains 5 grams sodium chlorid and 100 grams protein) or by Strauss diet consisting of $\frac{3}{4}$ liter of milk, 4 eggs, 150 grams of bread and enough fruit, fruit juice, tea and sugar to make it palatable Strauss diet contains about 3 grams of salt If the kidneys are able to excrete the amount of salt contained in these diets, salt may be added to either of them in quantities of 5 to 10 grams When the kidneys are unable to eliminate the normal quantity of salt, some form of salt poor diet may be advised but it should be stated that the salt poor diet has not entirely fulfilled the promises held out for it

A salt free diet is a practical impossibility unless one follows von Noorden's plan of giving 200 grams of lactose only The salt poor diets have been grouped under three headings

The strict salt poor diet of Widal (containing 1 5 to 2 5 grams of salt) consists of salt free bread 200 grams, meat 200 grams, vegetables 250 grams, butter 50 grams and sugar 40 grams This diet contains 60 grams of protein, and furnishes 1,700 calories, which is nearly sufficient energy for the average patient resting quietly in bed

The medium strict diet contains from 2 5 to 5 grams of salt The milk diet (3 liters) belongs here The food should be cooked without the addition of salt, but the patient should be allowed to use 2 to 3 gram of salt a day at the table

The moderate salt poor diet (5 to 10 grams) allows considerable latitude It is not necessary to prepare special dishes, but the cook should be instructed to use salt sparingly Salted foods such as bacon and ham, should be prohibited This diet furnishes only a rough control of the salt intake

In administering a salt poor diet, it is important that the energy

value of the food should not be permitted to fall below, nor to greatly exceed, the daily requirement of the patient

In addition to its employment in nephritis, the salt poor diet has been recommended for the edema of chronic cardiac valvular disease, for the ascites of cirrhosis of the liver pleurisy with effusion arterial sclerosis, and diabetes insipidus

SALT CONTENT OF FOODS

According to Leva

Food	Per Cent Sodium Chloride Raw Material
Meats	
Mutton	0 1
Veal	0 13
Calf's brain	0 20
Calf's kidney	0 [illegible]
Calf's liver	0 14
Beef (lean)	0 11
Pork (lean)	0 10
Venison	0 11
Fish	
Trout	0 1
Halibut	0 30
Herring	0 2
Cod	0 16
Carp	0 08[illegible]
Salmon	0 0[illegible]1
Mackerel	0 [illegible]8
Haddock	0 39
Oyster (washed)	0 [illegible]2
Oyster (with sea water)	1 14
Poultry	
Duck	0 14
Goose	0 [illegible]0
Chicken	0 14
Pigeon	0 15
Turkey	0 1[illegible]
Smoked and Salted Foods	
Ham (raw)	4 15—5 86
Ham (boiled)	1 8[illegible]—[illegible] 35
Salmon (smoked)	[illegible] 0
Bacon (smoked German)	1 01
Bacon (smoked American)	11 61
Corn beef German	[illegible] 04
Corn beef American	11 52
Cod (salt) *	23 00
Cod (salt boneless) *	19 00
Herring (smoked) *	11 70
Smoked and Salted Foods—Cont	
Mackerel (salt dressed)	10 40
Salmon (smoked salted)	10 8[illegible]
Sardines (French in oil)	1 34
Cod liver oil	0 17
Gelatin (dry)	0 [illegible]5
Beef marrow	0 11
Sausages Frankfurter	2 20
Sausages various kinds	2 90—8 10
Anchovy paste (Cross & Blackwell)	40 1
Meat Extracts	
Liebig's	2 60
Kemmerich	1 40
Various bouillon capsule extracts etc	9 40—22 0
Prepared Foods	
Plasmon	0 21
Poborat	0 00[illegible]1
Sanatogen	0 42
Somatose	0 66
Bovril's preparations	0 26—14 1
Valentine's Meat Juice	0 08—1 20
Egg (white and yolk)	0 [illegible]1
Egg (white alone)	0 31
Egg (yolk alone)	0 039
Caviar	3 00
Milk (whole)	0 16
Cream	0 13
Buttermilk	0 16
Whey	0 11—0 15
Condensed Milk	0 40
Butter (unsalted)	0 0[illegible]—0 21
Butter (salted)	1 00—3 00
Peanut butter *	4 10
Oleomargarine	2 1[illegible]
Palmin	0 0016
Fructin	0 10

* Analyses from Atwater and Bryant.

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The excretory power of the kidneys for salt may be tested by a diet of 3 liters of milk (this contains 5 grams sodium chlorid and 100 grams protein) or by Strauss' diet consisting of ¾ liter of milk, 4 eggs, 150 grams of bread, and enough fruit, fruit juice, tea, and sugar to make it palatable Strauss' diet contains about 3 grams of salt If the kidneys are able to excrete the amount of salt contained in these diets, salt may be added to either of them in quantities of 5 to 10 grams When the kidneys are unable to eliminate the normal quantity of salt, some form of salt poor diet may be advised, but it should be stated that the salt poor diet has not entirely fulfilled the promises held out for it

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SALT CONTENT OF FOODS

According to Leva

Food	Per Cent Sodium Chloride Raw Material	Food	Per Cent Sodium Chloride Raw Material
Meats		Smoked and Salted Foods—Cont	
Mutton	0 17	Mackerel (salt dressed)	10 40
Veal	0 13	Salmon (smoked salted)	10 97
Calf's brain	0 20	Sardines (French in oil)	1 34
Calf's kidney	0	Cod liver oil	0 17
Calf's liver	0 14	Gelatin (dry)	0 [illegible]5
Beef (lean)	0 11	Beef marrow	0 11
Pork (lean)	0 10	Sausages Frankfurter	2 [illegible]0
Venison	0 11	Sausages various kinds	2 90—8 10
Fish		Anchovy paste (Cross & Blackwell)	40 1
Trout	0 12		
Halibut	0 30	Meat Extracts	
Herring	0 27	Liebig's	2 60
Cod	0 16	Kemmerich	1 40
Carp	0 08[illegible]	Various bouillon capsules extracts etc	9 40—[illegible] 0
Salmon	0 0[illegible]1	Prepared Foods	
Mackerel	0 28	Plasmon	0 21
Haddock	0 [illegible]9	Roborat	0 0051
Oyster (washed)	0 52	Sanatogen	0 42
Oyster (with sea water)	1 14	Somatose	0 66
Poultry		Bovril's preparations	0 26—14 1
Duck	0 14	Valentine's Meat Juice	0 08—1 [illegible]0
Goose	0 [illegible]0	Egg (white and yolk)	0 21
Chicken	0 14	Egg (white alone)	0 31
Pigeon	0 15	Egg (yolk alone)	0 039
Turkey	0 17	Caviar	3 00
Smoked and Salted Foods		Milk (whole)	0 16
Ham (raw)	4 15—5 9[illegible]	Cream	0 13
Ham (boiled)	1 8[illegible]—5 3[illegible]	Buttermilk	0 16
Salmon (smoked)	7 50	Whey	0 11—0 15
Bacon (smoked German)	1 01	Condensed Milk	0 40
Bacon (smoked American)	11 61	Butter (unsalted)	0 0[illegible]—0 21
Corn beef German	2 04	Butter (salted)	1 00—3 00
Corn beef American	11 52	Peanut butter *	4 10
Cod (salt) *	[illegible]3 00	Oleomargarine	2 15
Cod (salt boneless) *	19 00	Palmin	0 0016
Herring (smoked) *	11 70	Fructin	0 10

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In administering a salt poor diet, it is important that the energy

Salt Content of Foods (Continued)

Food	[illegible]		[illegible]	
Drinks—Cont.			Foods [illegible]	
Apollinaris	0.043		Sauces	
Fachinger	0.0[illegible]9		Scrambled [illegible]	
Giesshübel (Mattoni)	0.0021		Spinach	
Vichy	0.0[illegible]3		Carrot	
Foods Prepared for Table			Cauliflower	
Bouillon	0.[illegible]—1.0		Green salad	
Thick soups	0.[illegible]4		Apple sauce	
Roast beef	0.93		Stewed [illegible]	
Roast pork	1.[illegible]4		Tapioca pudding [illegible]	
Chops	0.9[illegible]		Macaroni [illegible]	
Po[illegible] chicken	0.39		Rice with apples	

THE PURIN FREE DIET

Purin bodies preexist in the food and are formed within the body. The former are designated exogenous, the latter endogenous purins. Both animal and vegetable foods contain purins. Those of greatest interest to the physician are guanin, adenin, hypoxanthin, xanthin, uric acid, caffein (thein) and theobromin. The ingestion of exogenous purins raises the purin-content of the urine and in proportion to the amount taken, but

Purin Content of Foods (Reckoned as Uric Acid)

According to Schmid and Bessau, Walker Hall and H[illegible]

100 Grams	[illegible] Acid Grams	100 Grams	[illegible] Acid Grams
Beef	0.111—0.189	Salmon	0.0[illegible]—0.201
Mutton	0.078—0.191	Carp	0.16
Pork	0.1[illegible]3—0.1[illegible]	Herring	0.[illegible]
Veal	0.114—0.189	Sardines in oil	0.3[illegible]4
Ham (raw)	0.0[illegible]—0.139	Anchovy	0.4[illegible]
Tongue (calf)	0.16[illegible]	Oysters	0.08[illegible]—0.[illegible]
Brain (pig)	0.084—0.[illegible]3	Lobsters	0.0[illegible]
Liver (beef)	0.[illegible]—0.3[illegible]2	Caviar	0.110
Kidney	0.[illegible]40—0.[illegible]0	Cauliflower	0.0[illegible]4
Thymus (calf)	0.9[illegible]0—1.[illegible]0[illegible]	Spinach	0.0[illegible]2
Chicken	0.0[illegible]—0.136	Celery	0.01
Pigeon	0.1[illegible]4—0.1[illegible]4	Asparagus	0.0[illegible]4—0.0[illegible]
Goose	0.099	String beans	0.006
Venison	0.11[illegible]—0.1[illegible]	Potatoes	0.00[illegible]
Bouillon	0.04[illegible]—0.1[illegible]1	Mushrooms	0.01[illegible]—0.019
Meat Extract	2.000—[illegible].000	Peas	0.0[illegible]4—0.0[illegible]
Trout	0.[illegible]13	Lentils	0.0[illegible]—0.1[illegible]
Shellfish	0.11[illegible]	Beans	0.0[illegible]1—0.008
Cod	0.0[illegible]—0.131	Oatmeal	0.004

SALT CONTENT OF FOODS (Continued)

Food	Sodium Chloride per Kilo		
Drinks—Cont.		Foods Prepared for Table	
Apollinaris	0 043	Sauce	
Fachinger	0 0 9	Scrambled	
Giesshubel (Mattoni)	0 0071	Spinach	
Vichy	0 053	Carrot	
Foods Prepared for Table		Cauliflower	
Bouillon	0 —1 0	Green salad	
Thick soups	0	Apple sauce	
Roast beef	0 93	Stewed pear	
Roast pork	1 54	Tapioca pudding	
Chops	0 97	Macaroni	
Roast chicken	0 39	Rice with apples	

THE PURIN-FREE DIET

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PURIN CONTENT OF FOODS (RECKONED AS URIC ACID)

According to Schmid and Bessau, Walker Hall, and Hesse

100 Grams	Uric Acid Grams		Uric Acid Grams
Beef	0 111—0 189	Salmon	0 0 —0 201
Mutton	0 0 8—0 191	Carp	0 1
Pork	0 123—0 18	Herring	0 20
Veal	0 114—0 189	Sardines	0 3 4
Ham (raw)	0 0 2—0 130	Anchovy	0 4
Tongue (calf)	0 16	Oysters	0 08—0 1
Brain (pig)	0 034—0 2 3	Lobster	0 06
Liver (calf)	0 2 9—0 3 2	Caviar	0 110
Kidney	0 240—0 0	Cauliflower	0 0 4
Thymus (calf)	0 9 0—1 08	Spinach	0 0 2
Chicken	0 05 —0 186	Celery	0 01
Pigeon	0 1 4—0 154	Asparagus	0 0 4—0 0
Goose	0 099	String beans	0 006
Venison	0 11—0 18	Potatoes	0 006
Pouillon	0 01—0 1 1	Mushrooms	0 01 —0 019
Meat Extract	2 000— 000	Peas	0 0 4—0 0
Trout	0 13	Lentils	0 0 —0 1
Shellfish	0 11	Beans	0 0 1—0 093
Cod	0 0 —0 131	Oatmeal	0 0 4

less is excreted than is ingested. The excretion of endogenous purins is essentially constant for each individual.

The use of the purin free diet is based upon the theory that gout and some other disorders are dependent upon the retention of uric acid in the body. The diet has also been employed in diseases of the kidney, for some headaches, and "bilious attacks." (Proof is lacking, however, that the diet possesses definite value.)

FOODS CONTAINING NO PURINS

Bread	Beets
Cereals	Onions
Fruits	Port
Eggs	Sherry
Milk	Bordeaux
Cheese	

PURIN CONTENT OF BEVERAGES

According to Walker Hall and Labbe

100 Grams	Purin Bodies Reckoned as Uric Acid in Grams (Chiefly Methylpurins)	100 Grams	Purin Bodies Reckoned as Uric Acid in Grams (Chiefly Methylpurins)
Coffee (roasted)	1.24	1 Cup tea (Ceylon)	0.0805
Tea	1.35—3.58	1 Cup tea (Indian)	0.0700
Chocolate	1.43	1 Cup tea (Chinese)	0.025—0.046
Cocoa	1.30	1 Cup coffee	0.110—0.250
Beer	0.016	1 Cup chocolate	0.268—0.572
		1 Cup cocoa (10 grams)	0.130

PURIN NITROGEN CONTENT IN PER CENT

From Vogel

	Purin N		Purin N
Beef *	0.059	Oatmeal	0.030
Beef liver	0.099	Rice *	0.0004
Beef thymus	0.398	Potatoes *	0.001
Cod *	0.040	Spinach *	0.022
Wheat meal	0.001	Milk	0.0002
White bread	0.008	Swiss Cheese	0.0004
White bread *	0.005	Egg	0.0
Hominy	0.004	Tomatoes *	0.0

* Foods bought in America

METABOLISM IN FEVER

Total Metabolism.—The loss of weight, which until recently has always accompanied prolonged high fever, early led to the belief that the intensity of the metabolic processes in fever is increased. This belief

remained unchallenged for many years in fact, until attempts were made to calculate the heat production of patients with fever from measurements of the respiratory exchanges

The increase of the nitrogen excretion in the urine has generally been accepted as indicating a more rapid destruction of protein The discussions have centered around the total heat production and the extent to which carbohydrate and fat participated in the metabolic processes which bring about the increased heat production

A rise of the body temperature may be brought about by an increase in heat production without change in heat elimination by a decrease in heat elimination the heat production remaining unchanged, or by other disproportional alterations of heat production and heat elimination In probably no disease does the heat production reach such levels as normally occur during violent and prolonged muscular exertion yet the body temperature is not affected by it In exophthalmic goiter the metabolism may be 75 per cent above normal without producing fever Therefore, it is evident that increase in heat production alone is not sufficient to cause fever The heat regulating mechanism must be altered It is 'set' in fever for a higher level of body temperature just as a thermostat is set for a higher temperature in an incubator

Quantitative Changes —The total heat production of the body may be learned by direct measurement of the heat given off (direct calorimetry) or be calculated from the respiratory exchanges and the nitrogen of the urine (indirect calorimetry) Du Bois has shown with the aid of the calorimeter of the Russell Sage Institute of Pathology that the two methods agree within 2 2 per cent

The earliest studies of the total heat production in fever by indirect calorimetry give inconstant results In the majority of cases an increase was noted but other cases were observed in which it was normal or even decreased As a result of these differences the theory was advanced that fever might occur without increase in heat production, that is from decrease in heat elimination But the results obtained in the investigations of Coleman and Du Bois and the fact that many of the earlier observations have been proved unreliable inclined the author to the belief that fever is always accompanied by increased heat production There has always been an increase during the febrile period of typhoid The total metabolism was roughly parallel to the temperature curve, though there were considerable variations in different patients and in the same patient at different stages of the disease The average increase amounted to 40 per cent the maximum to something over 50 per cent

Without entering into the discussion of the significance of fever in the infective diseases, some of the factors to which the increase in heat production has been attributed require consideration

An early explanation ascribed the increase to the greater destruction

of protein This theory has been abandoned except in so far as the protein metabolism contributes to the general increase

Fr Mueller suggested that the increase in metabolism might be due in part to the increased rapidity of the heart and respiration and to muscular effort—restlessness, rigors The most recent studies indicate that the amount of energy liberated by the heart and muscles of respiration is insignificant when compared to the total, at least, it plays no considerable part in increasing heat production in fever In typhoid the pulse is characteristically slow But few observations have been made on the amount of energy required to perform muscular work in fever Svenson found in convalescence from typhoid that muscular work is not done economically It may not be done economically during the febrile period, yet according to evidence which we possess the increase in total metabolism is greater than could be accounted for by restlessness A patient was unusually quiet during the first hour of a three-hour period in the calorimeter during the second hour he was restless and tossed about the bed, during the third hour he was restless and irrational Yet during the whole period his metabolism was only 43 per cent above normal, and was only 5 per cent higher than it was during a quiet observation made two days later when the temperature was lower In the typhoid state, when the patient is rarely quiet, the increase in heat production from muscular effort must be great—it is conceivably doubled In the ordinary case of typhoid the amount of the increase from moving about the bed has been *estimated* to be about 10 per cent

The influence of food upon the total metabolism during the febrile period is negligible The increase from protein is 5 per cent, from carbohydrate 1 per cent In convalescence food has caused an increase of 16 per cent in heat production, but without affecting the body temperature

Qualitative Changes—*When the nitrogen of the urine is known*, the amounts of protein, carbohydrate, and fat consumed during stated periods may be calculated from the O_2 consumption and the respiratory quotient. The respiratory quotient, or coefficient, is the result obtained by dividing the CO_2 output by the O_2 consumed

By reason of its chemical composition, when carbohydrate is oxidized to carbon dioxid and water the amount of CO_2 liberated and O_2 consumed are equal and the respiratory quotient is 1 0 When fat is oxidized to the same end products the respiratory quotient is 0 7 When protein is oxidized to urea the quotient is 0 8 When the body transforms carbohydrate to fat the quotient is over 1 0, because fat is poorer in oxygen than is carbohydrate Since under actual conditions some protein is constantly metabolized, the respiratory quotient may vary from something over 0 7 to somewhat under 1 0 When the body is storing fat the quotient is slightly under, or over, 1 0

The respiratory exchanges of fever patients have been studied both

during the fasting state and after food The data which have been accumulated permit a reasonably clear conception of metabolic processes in fever to be formulated

The low respiratory quotients that is, under 0 7, which have been obtained by some observers, and which can only be interpreted by assuming that profound changes occur in the metabolic processes in fever, are now attributed to errors in technic

As will be seen later, the nitrogen metabolism probably is increased But no qualitative change in the nitrogen metabolism has been observed Protein is oxidized to the same end products as in health—urea principally—and liberates the standard amount of heat per unit of substance No qualitative changes are known in the metabolism of carbohydrate and fat Both are oxidized to carbon dioxid and water and similarly, produce the calculated amounts of heat The law of the conservation of energy obtains in fever as well as in health

The respiratory quotients prove that carbohydrate and fat are metabolized under the same general laws as in health—only the rate of utilization is changed When available carbohydrate is consumed in preference to, and in greater quantity than, fat, just as in health when an increased demand for energy has to be met When carbohydrate is not available, fat (of the food or body stores) is utilized It is still doubtful whether fat is as capable of protecting body protein as is carbohydrate In a mixed diet they appear to be equally good as protein sparers within limits which have not yet been determined The carbohydrate supply is more rapidly exhausted in fever than in health whether in the form of the unchanged carbohydrate of the blood or the glycogen of the tissues, and should be frequently replenished

Nitrogen Metabolism—On low diets the nitrogen metabolism is always increased in the infective fevers More nitrogen leaves the body in the urine than is taken in with the food Consequently the store of nitrogen is constantly depleted the patient is said to be in negative nitrogen balance In severe forms of the infective fevers, such as pneumonia and typhoid, the losses relatively speaking may be very great In general the extent of the loss is proportional to the severity of the infection It is always greater than in simple starvation

This loss of nitrogen in the infective fevers has been known for many years and has been called the *febrile or toxic destruction of protein* Accordingly it has been considered a characteristic phenomenon of infective fevers

Several conceptions of the nature of the process are found in the extensive literature on the subject Von Leyden and Klemperer describe it as a loss of nitrogen which cannot be prevented by food According to Benedict and Surany1, it is merely an expression of the increase in total metabolism Krehl and Fr Mueller use the term to indicate direct

injury to the cells of the body by the toxin of the infecting organism These different conceptions have led to much confusion in discussions of the subject It should be stated here that Grafe and his pupil, Rolland, deny the existence of a toxic destruction of protein in fever

By their success in bringing patients with severe attacks of typhoid fever into nitrogen equilibrium Shaffer and Coleman showed that the conception of von Leyden and Klemperer is no longer tenable

The main objection to the theory of Benedict and Surinyi lies in the fact that the nitrogen metabolism of normal men does not rise with the increase in total metabolism which occurs during muscular effort More over the increase in nitrogen metabolism appears to be greater than can be explained by the increase in total metabolism in fever

Krehl s theory of the toxic destruction of protein is at present the center of active discussion The opponents of the theory, when not denying its occurrence, maintain that the increase in nitrogen metabolism is due to the rise in the body temperature rather than to an injurious action of toxins on the cells

Influence of High Temperature—A large number of experiments have been performed on lower animals and man in the attempt to discover the extent to which nitrogen metabolism is influenced by high temperature The body temperature has been raised artificially by puncture of the heat center by hot air, hot water, and steam baths and the nitrogen output determined The nitrogen output of patients with various types and heights of temperature curves has been studied during the febrile and afebrile periods

The results of these experiments have not been uniform Senator and Richter explain negative results by saying that increase in the metabolism of protein occurs only when the high temperature is maintained for a number of hours and that the increase of nitrogen in the urine may not at once be apparent Graham and Poulton experimenting upon themselves did not succeed in increasing the nitrogen output by raising the body temperature by steam baths

The observations in various febrile diseases and on experimentally infected animals have been equally inconstant In some instances the nitrogen excretion has paralleled the temperature curve, in some it has been high when the temperature has been low and an increase in the nitrogen excretion has been observed before the rise in temperature occurred Linser and Schmid state that the nitrogen excretion is affected only by temperatures of 39° C and over

Influence of Toxins—The discrepancies in the relation of the nitrogen excretion to the body temperature led to a search for other causes Krehl attributes the increase in nitrogen metabolism to a deleterious action of the toxin of the invading organism on the cells of the body

Commenting on May's experiments on animals Fr Mueller says the

fact that carbohydrate diminishes the protein loss in fever would not disprove the theory of a toxic destruction until it had been shown that like amounts of carbohydrate reduce the nitrogen exchanges of men with high fever to as low a level as in health Shaffer and Coleman have shown that this is impossible in typhoid fever Their patients could not be brought into nitrogen equilibrium until they were given amounts of food representing an energy value of 50 per cent to 100 per cent above their heat production (computed from measurements made later with the Benedict "universal" apparatus and the Sage calorimeter) It was also found that the nitrogen intake could not be reduced much below 10 grams without throwing the patient out of nitrogen balance Rolland's patients with sepsis, paratyphoid and acute pulmonary tuberculosis had a nitrogen metabolism not greater than the lowest requirements in health She brought them into balance on amounts of protein slightly greater or within the figures given by Rumpf and Schumm (1 15 grams per kilogram) and by Chittenden (0 7 grams per kilogram), but with an excess of carbohydrate She did not take the nitrogen minimum into consideration that is the smallest amount of nitrogen to which a healthy man can be reduced for short periods, together with sufficient amounts of carbohydrate and fat to cover his energy requirement without developing a negative nitrogen balance

Recently Kocher, working under Fr Mueller's direction has made a further study of the subject. He compared the effect of an increase in the total metabolism (through strenuous exercise) of two healthy individuals upon their nitrogen minima with the nitrogen excretion of fever patients on diets containing essentially the same quantities of protein and amounts of energy which *he calculated* were sufficient to bring them into nitrogen equilibrium Since the fever patients lost nitrogen, while the healthy men did not, he concluded that the occurrence of a toxic destruction had been established Kocher's experiments are open to the objection that he did not first bring his patients into equilibrium and then reduce the protein as Shaffer and Coleman did Grafe has published experiments on animals which he claims disprove Kocher's conclusion

The author believes that the protein metabolism is increased in the infective fevers The fact that typhoid patients cannot be brought into nitrogen equilibrium unless they receive from 10 to 15 grams of nitrogen a day and an amount of energy from 50 per cent to 110 per cent greater than their heat production can in his opinion be interpreted in no other way But whether the increase in protein metabolism is due to the elevation in temperature or to injury from the toxins is, likewise in his opinion an open question

The most important consideration for the practitioner is that it is possible to nourish fever patients in a manner which prevents loss of nitrogen to the body

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from 50 to 110 per cent more energy than the heat production This is probably true for many infective fevers There is some disagreement whether patients should be given such large amounts of food, but patients digest them well, and the author can see no justification for permitting a gratuitous loss of protein Expressed as energy, patients with severe fever require from 3,000 to 4,000 calories a day If they complain of hunger, as typhoid patients frequently have while taking this amount the food may be increased The author has permitted as much as 7,600 calories

The amount of protein which the patient needs varies from 60 grams to 90 grams Patients lose nitrogen if less than 60 grams be given, and they derive no benefit from more than 90 grams

Carbohydrate is consumed in preference to fat, whenever it is available and should be the main reliance for maintaining the energy value of the diet When the desired amount of carbohydrate is not easily digested, the quantity of fat may be gradually increased The arrangement of dietaries will be simpler if fat is included (butter and cream) and with some patients it must be depended upon to supply the greater portion of the energy As much as 300 grams of fat a day has been given.

One of the most important considerations in the dieting of fever patients is *individualization* Every effort should be made to 'feed the fever,' but this can be accomplished only if the patient digests and absorbs the food he receives With so many foods from which to choose, it will rarely be necessary to insist upon a patient's taking foods he dislikes His desires should be followed as far as is feasible both in the selection and preparation of his food

Foods which disagree should be avoided Torrey has shown that the inability of the typhoid patient to digest his food is associated with a predominance of a putrefactive flora in the intestine The equally important fact disclosed by his investigation, was that favorable fermentative types of organisms usually gain the ascendency on diets rich in carbohydrate

Much greater variety in food may be allowed than was formerly thought permissible

The author has practically abandoned the use of the milk diet except for brief periods and under unusual circumstances Milk is a valuable addition to many dietaries but alone it furnishes too much protein and too little energy If a carbohydrate is taken with it, such as bread crackers, simple cake it is not only more easily digested but patients enjoy it more Milk may serve also as a vehicle for other foods—milk sugar, eggs and cream

The food should be served as far as possible in the form and manner most likely to stimulate the patient's desire for it Small quantities at

Absorption of Food in Fever.—Von Hoesslin found in 1882 that food is absorbed by typhoid patients almost as well as in health, in spite of the fact that most of his patients suffered from diarrhea. About the same time (1883) similar observations were made in Chudnowsky's clinic in Russia. Von Leyden and Klemperer's patients with high fever lost in the stools 6 per cent to 11 per cent of fat and 9 per cent of protein. No carbohydrate was lost except when large amounts were given or the patients had profuse diarrhea. Recently Du Bois has reinvestigated the question of food absorption in typhoid fever, using more reliable methods of analysis. He found the losses to be as follows: There was no loss of carbohydrate except when the patients were taking more than 300 grams a day, then it amounted to only 2 or 3 grams, the average loss of protein was 7 per cent, the average loss of fat for all stages of the disease was 6 per cent (the loss of normal controls on the same diet was 3 per cent), for the early stages the loss was 7 per cent, for the later 4.5 per cent. It should be added that the patients were taking large amounts of fat. In Coleman and Gephart's typhoid patients the average fat loss in all periods of the disease was 4.3 per cent. No differences were observed between the early and later stages. The nitrogen losses averaged 11 per cent.

These observations prove that in typhoid fever, and probably in other febrile diseases, the absorption of food is nearly as complete as in health.

Fever Diet

The facts which have been obtained through studies of metabolism in fever have removed all doubt that patients with fever require more food than healthy men, unless engaged in heavy labor. The only question is whether fever patients can take the amount of food they need without detriment. The answer is to be found in clinical tests, without which it is impossible to estimate the value of any therapeutic procedure. These tests have been made on a large scale, and the results prove not only that fever patients can take without harm the amount of food they need, but that they are benefited by doing so.

Diets which do not furnish enough energy to cover the patients' heat production compel them to live in part at the expense of their own tissues. Experiments with such diets extend back some 2,000 years in medical history, and the results to say the least have been disappointing and the old doctrine of "starving a fever" is fundamentally erroneous.

The food needs of the fever patient may be summarized as follows:

The total energy required is always greater than in health. In general, the higher the temperature, the greater the need for food. In typhoid fever the body protein is not protected unless the food furnishes

Toast Water (Cautley).—Pour a pint of boiling water over two or three slices of well toasted bread. Let it stand until cool, strain.

The calory value of this preparation is negligible.

Chicken Broth (Bartholow).—Skin and chop fine a small chicken or half of a large fowl and boil it, bones and all, with a blade of mace, a sprig of parsley, and a crust of bread, in a quart of water for an hour, skimming it from time to time in order to remove the excess of fat from the broth. Strain through a coarse colander.

The composition of chicken broth is: 84.3 per cent water, 10.5 per cent protein, 0.8 per cent fat, 2.4 per cent carbohydrate, 2 per cent ash. *It furnishes 56 calories to 100 c. c.*

Chicken Jelly (Adams).—Clean a fowl that is about a year old, remove skin and fat, chop bones and flesh fine, place in a pan with two quarts of water, heat slowly, skim thoroughly, simmer five to six hours, add salt, mace or parsley to taste, strain, and cool. When cool skim off the fat. The jelly is usually relished cold but may be heated. Data for estimating the calory value of this preparation are not available.

Beef Tea (Cautley).—1. Mince one pound of lean beef and add to it one pint of cold water and ten drops of dilute hydrochloric acid. Let it stand for two or three hours with occasional stirring, and then simmer for ten to twenty minutes. Do not let it boil. Skim well.

2. Mince one pound of lean beef as fine as possible, and pound it in a mortar with a small teaspoonful of salt. Add the meat and its juice to one pint of water at 170° F. in an earthen vessel and stand it for an hour by the fire, stirring at times. Then strain it through muslin, taking care to squeeze all the juice out of the meat.

The composition of beef tea is: 92.0 per cent water, 4.4 per cent protein, 0.4 per cent fat, 1.1 per cent carbohydrate, 1.2 per cent ash. *It furnishes 25 calories to 100 c. c.*

Invalid Broths (Thompson).—To one pound of chopped lean meat, either chicken, mutton or beef, add one pint of cold water, let stand in a covered glass fruit jar from four to six hours, cook for three hours in a closed jar over a slow fire, strain, cool, skim off the fat, clear with egg, season, and feed warm or cold.

These broths, except the chicken broth, possess essentially the same fuel value as beef tea.

Beef Juice (Bartholow).—Broil quickly some pieces of round or sirloin steak of a size to fit in the cavity of a lemon squeezer previously heated by dipping in hot water. The juice should be received into a hot colored (preferably red) wine glass, seasoned to taste with salt and cayenne pepper, and taken hot.

Beef Juice (Cautley).—Chop lean beef fine, or scrape with a fork or meat scraper to separate the connective tissue, and put it in a jar or cup, with a pinch of salt and enough cold water to cover it. Allow

frequent intervals—but not oftener than every two hours—are digested more easily than fewer, but larger, meals. In severe fevers the patient should be waked for his food, except perhaps during the early morning hours.

The appetite may be stimulated and flow of gastric juice started by beginning the larger meals with two to four ounces of meat soup. This amount will not compromise stomach room.

The foods which the author has found most useful are: milk, cream, eggs, bread or toast, crackers, well boiled and bran free cereals, rice, well cooked potato, butter, bacon (as a relish), milk sugar, cane-sugar, tea and coffee (as vehicles and for variety), cocoa, apple sauce, orange juice, lemonade, and grape juice.

Any digestible combination of these foods may be given (see Invalid's Dietary).

The more easily digested meats may be permitted in small quantities once a day, preferably at midday. Foods containing cellulose may be allowed to patients whose alimentary tracts are not the seat of pathological processes.

INVALID'S DIETARY

Oatmeal Gruel (plain) (from *Food*).—Two tablespoonfuls of granulated oatmeal (45 grams, 184 calories), one saltspoonful of salt, one scant teaspoonful of sugar (8 grams, 33 calories), one cupful of boiling water, one cupful of milk (300 grams, 216 calories). Mix the oatmeal, salt and sugar together, and pour on the boiling water. Cook for thirty minutes, then strain through a fine wire strainer to remove the hulls; place again on the stove, add the milk, and heat just to the boiling point. Serve hot.

This gruel furnishes 425 calories.

Barley Water (Cutler).—*Thin.*—Put a teaspoonful of prepared or pearl barley, previously washed in cold water, into a jug; pour half a pint of boiling water on it; add a pinch of salt, stand it by the fire for an hour, stirring occasionally, and strain through fine muslin. Similar thin cereal decoctions may be made from rice, arrowroot, or oatmeal. It furnishes about 7 calories per 100 c.c.

Thick.—Put a heaped tablespoonful of washed prepared, or pearl barley into a clean sauce-pan and add a quart of water and a pinch of salt. Boil slowly until it has evaporated down to about two-thirds of a quart and strain. It may be flavored as desired. The addition of a little lemon peel, while boiling, is best.

The composition of barley water is: 0.09 per cent protein, 0.05 per cent fat, 1.6 per cent carbohydrate.

It furnishes 14 calories to 100 c.c.

Toast Water (Cautley) —Pour a pint of boiling water over two or three slices of well toasted bread Let it stand until cool strain.

The calory value of this preparation is negligible

Chicken Broth (Bartholow) —Skin and chop fine a small chicken or half of a large fowl, and boil it bones and all, with a blade of mace a sprig of parsley, and a crust of bread in a quart of water for an hour, skimming it from time to time in order to remove the excess of fat from the broth Strain through a coarse colander

The composition of chicken broth is 84 3 per cent water, 10 5 per cent protein 0 8 per cent fat 2 4 per cent carbohydrate, 2 per cent ash

It furnishes 56 calories to 100 c c

Chicken Jelly (Adams) —Clean a fowl that is about a year old remove skin and fat, chop bones and flesh fine, place in a pan with two quarts of water heat slowly skim thoroughly simmer five to six hours add salt mace, or parsley to taste strain and cool When cool skim off the fat The jelly is usually relished cold but may be heated Data for estimating the calory value of this preparation are not available

Beef Tea (Cautley) —1 Mince one pound of lean beef and add to it one pint of cold water and ten drops of dilute hydrochloric acid Let it stand for two or three hours, with occasional stirring and then simmer for ten to twenty minutes Do not let it boil Skim well

2 Mince one pound of lean beef as fine as possible and pound it in a mortar with a small teaspoonful of salt Add the meat and its juice to one pint of water at 170 F in an earthen vessel and stand it for an hour by the fire stirring at times Then strain it through muslin, taking care to squeeze all the juice out of the meat

The composition of beef tea is 92 9 per cent water, 4 4 per cent protein, 0 4 per cent fat, 1 1 per cent carbohydrate 1 2 per cent ash

It furnishes 25 calories to 100 c c

Invalid Broths (Thompson) —To one pound of chopped lean meat either chicken, mutton or beef add one pint of cold water, let stand in a covered glass fruit jar from four to six hours, cook for three hours in a closed jar over a slow fire, strain, cool, skim off the fat, clear with egg season, and feed warm or cold

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Beef Juice (Cautley) —Chop lean beef fine or scrape with a fork or meat scraper to separate the connective tissue and put it in a jar or cup with a pinch of salt and enough cold water to cover it Allow

it to stand from one to six hours, and then squeeze well through coarse muslin It may be given alone or mixed with other foods, warm or cold—not hot It should be warmed by heating the vessel in hot water

Beef Juice (Ringer) —Take one ounce of fresh beef, free from fat, chop fine, and pour over it eight ounces of cold water, add five or six drops of dilute hydrochloric acid, and fifty to sixty grains of common salt, stir it well, and leave for three or four hours in a cool place Then pass the liquid through a hair sieve, pressing the meat slightly, and adding gradually toward the end of the straining about two more ounces of water The liquid thus obtained is of a red color, possessing the taste of soup It should be taken cold, a teaspoonful at a time If preferred warm, it must not be put on the fire, but heated in a covered vessel placed in ho water

The composition of beef juice is 90 6 per cent water, 5 0 per cent protein, 0 6 per cent fat

It furnishes 25 calories to 100 c c

Beef Pulp (Cautley) —Scrape a piece of raw lean rump or sirloin steak with a fork or meat scraper until as much as possible of the muscular tissue has been obtained, separated from the tendinous parts Pound it in a mortar to a pulp, and then rub it through a fine sieve Season with pepper and salt It may be taken in the form of sandwiches, or rolled up into small rissoles and lightly grilled or fried

Very little of the nutriment of the meat is lost in this process

Egg Albumin Water (Watson) —Take the white of an egg (30 calories) and to it add twice its own volume of water and strain through muslin This gives about three ounces of a clear solution, containing as much protein as is found in the average sample of commercial beef juice

This fluid, added to home-made beef tea, makes a nutritive solution almost indistinguishable from beef juice and at a fraction of the cost Mix while cool in order not to precipitate the proteins

Egg Albumin Water (Cautley) —Take the white of a fresh egg (30 calories) and cut it in numerous directions with scissors Shake it up *in a flask with a pinch of salt* and six ounces of cold water Strain through muslin

It can be made with thin barley water, and cream or sugar added

Egg nog —The following recipe makes a glass and one half of egg nog

Egg, 1 large (60 grams)	80 calories
Sugar, 1 tablespoonful (30 grams)	120 "
Whisky, 2 tablespoonfuls	90 "
Cream, 7 tablespoonfuls	210 "

Add the sugar to the yolk of egg and beat until very light Whip the white of the egg and then the cream until very stiff Add the whisky to the yolk of egg and sugar Mix well Add one half the cream to this then one half the beaten white of egg then the remaining cream, and finally the remaining white of egg Mix lightly

Egg nog (Bartholow) —Scald some new milk by putting it, contained in a jug into a saucepan of boiling water, but it must not be allowed to boil Beat an egg with a fork in a tumbler with some sugar add a dessertspoonful of brandy and fill the tumbler with the scalded milk when cold

This egg nog will furnish about 300 calories

Savory Custard (Anderson) —Add the yolks of two eggs to a cupful of beef tea with pepper and salt to taste Butter a cup or a jam pot pour the mixture into it and let it stand in a pan of boiling water till the custard is set

This will furnish 150 calories

Egg Flip —Boil or heat thoroughly a teacupful of milk beat the white of one egg to a froth Pour the milk over the egg, stirring constantly Add sugar to taste

This will furnish 230 calories

Caudle (Yeo) —Beat an egg to a froth add a glass of sherry and half a pint of gruel Flavor with a lemon peel nutmeg and sugar The gruel may be made either with water or milk

This will furnish from 120 to 1 0 calories according to the consistency of the gruel If milk is used to make the gruel it will have a higher value

Boiled Rice (U S Army Hospital Recipe) —Rice one ounce (30 grams) salt, twenty grams water four ounces *Directions* —Put the salt and water into a stewpan When boiling add the rice, previously washed thoroughly Boil for ten minutes or until each grain becomes soft Drain it on a colander Grease the stewpan with clarified drippings or lard Put back the rice Let it swell slowly near the fire, or in a slow oven for about twenty minutes until the grains are well separated

Boiled rice furnishes 60 calories to 1 tablespoonful

Rice Pudding

Rice	3 tablespoonfuls (100 grams)	360 calories
Milk	1 quart	700 "
Salt	1 pinch	

Wash the rice with water Add to the milk and cook slowly on top of the stove for one hour, or a little longer, until the mixture becomes creamy

Add

Sugar	1 cup (280 grams)	1,148 calories
Butter	1 heaping teaspoonful	120 "

Cinnamon, nutmeg, or vanilla to taste

Put into a dish to set and bake in an oven until the top is browned

The whole pudding contains 2,325 calories It furnishes five to six portions

Rice Pudding (Cautley) —Cover the bottom of a dish with clean rice, nearly fill with milk, and add sugar, put it in a slow oven for three hours, and in the hottest part of the oven for fifteen minutes

With the indefinite statement of the amounts of the ingredients, the calorie value of this preparation cannot be estimated

Rice and Egg Pudding (Cautley) —Take three ounces (90 grams, 315 calories) of rice and swell it gently in one pint of new milk (350 calories) Let it cool, and stir well into it one ounce of fresh butter (230 calories), two ounces of powdered sugar (240 calories), the yolks of three eggs (150 calories) and some grated lemon peel Pour into a well buttered dish and put on the top the whites of the three eggs (96 calories), beaten with three tablespoonfuls of powdered sugar (185 calories) Bake for twenty minutes until lightly browned

The whole pudding contains 1,550 calories

Arrowroot (Pavy) —Mix thoroughly two teaspoonfuls of arrowroot with three tablespoonfuls of cold water, and pour on them half a pint of boiling water, stirring well meanwhile *If the water is quite boiling, the arrowroot thickens as it is poured on, and nothing more is necessary If only warm water is used, the arrowroot must be afterward boiled until it thickens* Sweeten with loaf sugar, and flavor with lemon peel or nutmeg, or add sherry, port wine, or brandy, if required Boiling milk may be employed instead of water, but when this is done no wine must be added as the milk would curdle

Cocoa Junket [a]

Cocoa	1 teaspoonful	50 calories
Milk sugar	25 grams	100 "
Milk, 5 oz	150 c c	100 "
Junket tablet	1/4	
Cold water	1 oz	

Dissolve the junket tablet in the water Mix the cocoa and sugar, add the milk, and heat lukewarm, stirring constantly, add the dissolved junket tablet, stir thoroughly, and leave in a warm place to set

[a] This and the following recipes were published in the American Journal of Medical Sciences for January 1910

Soft Custard

Milk	1 cup (8 oz)	160 calories
Egg	1	80 "
Milk sugar	60 grams	240 "
Salt	a speck	
Vanilla	2 to 3 drops	
Caramel, made of granulated sugar	3 tablespoonfuls	20 "

Beat the egg slightly add the sugar salt, and hot milk slowly Cook in a double boiler, stirring constantly until it thickens a little (if cooked too long the custard will curdle but may become smooth again if set in a dish of cold water and beaten at once) Flavor and cool

To make caramel put the sugar in a pan directly over heat and burn until a very dark brown Dissolve in hot water or milk.

Plain Junket or Rennet Custard

Milk sugar	25 grams	100 calories
Milk	5 oz (150 c c)	100 "
Junket tablet	1/4	
Cold water	1 oz	
Vanilla	few drops	

See directions for Cocoa Junket

Baked Custard

Milk sugar	40 grams	160 calories
Milk	6 oz (180 c c.)	120 "
Egg	1	80 "
Nutmeg or vanilla		
Salt	a speck	

Beat the egg slightly warm the sugar and milk stirring constantly, add to the egg strain into a custard cup and flavor Bake in a pan of water in a moderate oven until a knife when cut into it, will come out clean (1/2 to 1 hour)

Bread Pudding

Milk sugar	45 grams	180 calories
Milk	6 oz (180 c c)	120 "
Egg	1	80 "
Bread	1 slice 3/8 thick 20 grams	60 "
Butter	1/2 oz (15 grams)	120 "

Spread the bread with butter, and cut into squares Beat the egg slightly, heat the milk and sugar, stirring constantly, mix with the egg and pour over the bread Grate nutmeg over the top and bake the same as custard

Vanilla Ice Cream

Cream	4 oz (120 c c)	240 calories
Milk	2 oz (60 c c)	40 "
Milk sugar	60 grams	240 "
Vanilla	few drops	

Mix the cream, milk, and sugar and heat, stirring constantly, until the sugar is dissolved Then flavor, cool, and freeze

Cocoa with Milk

Cocoa	1 rounding teaspoonful	50 calories
Milk sugar	60 grams	240 "
Milk	4 oz (120 c c)	80 "
Cream	2 oz (60 c c)	120 "

Mix the sugar and cocoa, cook in the milk until dissolved Serve with the cream

Cocoa

Cocoa	1 heaping teaspoonful	50 calories
Milk sugar	60 grams	240 "
Water	½ cup, 4 oz	
Cream	3 oz (90 c c)	180 "

Mix the cocoa and sugar, add the water, and boil for four or five minutes Then add the cream, or use less and serve with whipped cream

Coffee

Milk sugar	60 grams	200 calories
Strong coffee	4 5 oz	
Cream	2 oz (60 c.c)	120 "

Milk sugar may be used likewise to sweeten tea which may be served with or without cream

Lemonade

Milk sugar	120 grams	480 calories
Cold water	7 oz (210 c c)	
Lemon juice	2 tablespoonfuls (or to taste)	

Boil the sugar and water two minutes Add lemon juice to taste, strain, and cool. The white of an egg may be added if desired

Orangeade

Juice of 1 2 oranges	100 200 calories
Milk sugar, 50 100 grams	200-400 "

Mix the orange juice and sugar and serve in a glass with cracked ice

PROPRIETARY FOODS

A great variety of proprietary foods are manufactured Practically all of them are made from common articles of diet, such as meat, eggs milk grain, etc

Proprietary foods possess no special nutritive virtues, as is so often claimed which are not possessed by the natural foods from which they are manufactured Neither do they possess any medicinal value unless some drug has been added to them Some proprietary foods are partially digested. The predigested protein foods have an unusual and often dis agreeable taste, and for this reason fail to stimulate the "appetite juice There is no evidence that predigested protein foods are more completely absorbed than natural foods In fact, they are likely to cause digestive disturbances and diarrhea as Voit long ago pointed out Some of them contain alcohol, as much as 22 per cent If such a food is given as the sole or principal article of diet, the patient is likely to be kept in a state of constant exhilaration or intoxication

Carbohydrate proprietary foods are said to have been predigested when a portion or all of the starch has been converted into sugar (or sugars) They are neither more easily digested nor more completely absorbed than the sugar (or sugars) into which the starch has been changed The proprietary carbohydrate foods in general possess greater nutritive value than the protein foods

As Lusk has said the chief value of proprietary foods lies in their taste—and this is not always pleasing Some proprietary foods may be useful at times in order to gratify a patient s desire for change of flavor Some are useful for modifying other foods especially milk Few, if any, of them should ever constitute the sole article of diet, except for the briefest periods or under exceptional circumstances. On account of their peculiar taste or because of the lack of adaptation of the digestive glands (cf Pavlov), it is always difficult to give proprietary foods in sufficient quantity to meet the energy requirements of the body without causing disturbances of digestion. Another, and more impor

tant, fact is that the deficiency of vitamins in proprietary foods has been observed to produce serious disorders of metabolism, especially in children.

The composition of various proprietary foods is given in the following tables:

ANALYSES OF SOLID MEAT EXTRACTS *

Name	Per Cent Moisture	Per Cent Total Ash	Per Cent Chlorine as Sodium Chloride in Ash	Per Cent Total Insoluble Proteins †	Per Cent Total Meat Bases
Armour's Extract of Beef	21.66	20.46	5.47	2[illegible].[illegible]1	9.[illegible]
Beef Extract, Swift & Co.	20.16	27.28	13.[illegible]1	1[illegible].38	10.70
Beef Extract, Corn Special, G. H. Hammond Co.	12.39	31.68	13.2[illegible]	1[illegible].01	13.14
Extract of Beef Premier, Libby, McNeill & Libby	21.80	30.92	18.32	14.93	9.98
Liebig's Extract of Meat	21.14	21.03	3.11	30.50	11.9[illegible]
"Rex" Brand Beef Extract, Cudahy Packing Co.	[illegible].50	24.06	8.54	2[illegible].12	11.11

* U. S. Dept. of Agriculture, Bureau of Chemistry, Bull. No. 114.
† The sum of insoluble and coagulable proteins, proteoses and peptones.

ANALYSES OF FLUID MEAT EXTRACTS *

Name	Per Cent Moisture	Per Cent Total Ash	Per Cent Chlorine as Sodium Chloride in Ash	Per Cent Total Proteins †	Per Cent Total Meat Bases
Beef Juice, Wyeth & Bro.	58.84	1[illegible].21	6.71	6.4[illegible]	5.99
Concentrated Fluid Extract of Beef, Armour & Co.	57.7[illegible]	17.[illegible]3	8.27	6.76	5.18
Fluid Beef Jelly, Mosquera-Julia Food Co.	6[illegible].97	13.[illegible]5	10.0[illegible]	8.1[illegible]	3.06
Fluid Extract of Beef, Cibils Co., Importers	64.[illegible]3	16.13	11.38	10.[illegible]5	4.[illegible]4
Meat Juice, Valentine's Meat Juice Co.	57.64	10.26	1.77	5.63	6.0[illegible]
Rex Fluid Beef Extract, Cudahy Packing Co.	5[illegible].9[illegible]	16.99	8.48	7.00	8.[illegible]1
Vigoral, Armour & Co.	49.94	15.91	7.02	10.75	6.30

* U. S. Dept. of Agriculture, Bureau of Chemistry, Bull. No. 114.
† The sum of insoluble and coagulable proteins, proteoses and peptones.

There are various other meat extracts on the market but the average analyses of the different brands are so nearly alike that the various constituents will not differ markedly from the above figures.

MISCELLANEOUS PREPARATIONS (MEAT EXTRACTS JUICES AND POWDERS)*

Name	Per Cent Water	Per Cent Total Ash	Per Cent Chlorin as Sodium Chlorid in Ash	Per Cent Total Protein†	Per Cent Total Meat Bases
Bouillon Capsules Royal Specialty Co	14 7[illegible]	39 75	29 72	22 19	6 93
Bovril seasoned	43 39	1[illegible] 09	8 73	27 06	6 02
Beef Jelly Mosquera Julia Food Co	7 89	17 31	8 39	28 63	9 24
Essence of Beef Brand & Co	90 93	1 34	0 09	[illegible] 07	1 [illegible]4
Predigested Beef H K Mulford Co	91 69	0 18	0 01	1 19	0 69
Soluble Beef Armour & Co	30 1[illegible]	14 [illegible]5	5 91	3 [illegible]6	6 6[illegible]
Bovox Essence of Beef The Bovox Co	6[illegible] [illegible]7	17 29	9 73	16 [illegible]7	2 [illegible]8
Johnson s Fluid Beef	4[illegible] [illegible]2	9 80	4 [illegible]7	31 75	3 87
American Brand Extract of Beef American Beef Extract Co	27 54	[illegible]4 73	24 73	2[illegible] 69	3 59
Bovinine Concentrated Beef The Bovinine Co	80 40	1 55	1 05	14 14	0 9[illegible]
Essence of Mutton The London Essence Co	8[illegible] 03	2 9[illegible]	0 18	12 00	1 78
Liquid Food Murdock Liquid Food Co	86 09	0 65	0 90	10 69	0 25
Maggi s Bouillon	5[illegible] 5[illegible]	91 94	17 5	2 13	5 83
Peptonized Beef Ro e	45 13	3 52	1 63	22 90	9 89
Beef Extract and Vegetable Tablet Armour & Co	[illegible] 29	23 6[illegible]	18 14	18 87	3 15
Leube Rosenthal s Beef Solution	7[illegible] 68	3 91	1 84	16 13	1 34
Malted Meat Extract of Beef American Malted Meat Co	8 61	7 87	3 48	9 82	1 40

* U S Dept of Agriculture Bureau of Chemistry Bull No 114 1908
† The sum of the soluble and coagulable proteids, proteoses and peptones

The following table giving the composition of meat juices prepared in the laboratory, illustrates the nutritive value of home-made as compared with commercial products Bigelow and Cook [10] state that meat juice prepared in the home or hospital is far superior as a food to the commercial meat extracts and so-called meat juices '

MEAT JUICES PREPARED IN LABORATORY *

Name	Per Cent Water J	Per Cent Ash	Per Cent Chlorin as Sodium Chlorid in Ash	Per Cent Insoluble Protein	Per Cent Coagulable Proteins
Round beef cold pressed	85 [illegible]6	1 53	0 19	1 00	8 56
Round beef pressed at 60 C	90 [illegible]	1 36	0 15	4 95	
Juice extracted from sirloin steak by cold pressure	96 13	0 46	0 0[illegible]	2 13	
Juice extracted from beef chuck by cold pressure after 6 hours at 60-100 C	98 11	0 [illegible]9	0 0[illegible]		

U S Dept of Agriculture Bureau of Chemistry Bull No 114 1908

* U S Dept of Agriculture Bureau of Chemistry Bull No 114 1908

tant, fact is that the deficiency of vitamins in proprietary foods has been observed to produce serious disorders of metabolism, especially in children

The composition of various proprietary foods is given in the following tables

ANALYSES OF SOLID MEAT EXTRACTS *

Name	Per Cent Moisture	Per Cent Total Ash	Per Cent Chlorine as Sodium Chloride in Ash	Per Cent Total Proteins †	Per Cent Total Meat Bases
Armour's Extract of Beef	21.66	20.46	5.47	27.51	9.[illegible]
Beef Extract Swift & Co	20.16	27.28	13.51	15.38	10.10
Beef Extract Coin Special G H Hammond Co	12.30	31.68	13.25	15.01	13.14
Extract of Beef Premier Libby McNeill & Libby	21.86	30.92	18.32	14.95	9.98
Liebig's Extract of Meat	21.14	21.03	3.11	30.50	11.9[illegible]
"Rex" Brand Beef Extract Cudahy Packing Co	26.50	24.06	8.54	22.12	11.11

* U S Dept of Agriculture Bureau of Chemistry Bull No 114
† The sum of insoluble and coagulable proteins, proteoses and peptones

ANALYSES OF FLUID MEAT EXTRACTS *

Name	Per Cent Moisture	Per Cent Total Ash	Per Cent Chlorine as Sodium Chloride in Ash	Per Cent Total Proteins †	Per Cent Total Meat Bases
Beef Juice Wyeth & Bro	58.84	16.21	6.71	6.45	5.99
Concentrated Fluid Extract of Beef Armour & Co	57.75	17.25	8.97	6.76	5.18
Fluid Beef Jelly Mosquera Julia Food Co	68.97	15.85	10.05	8.13	3.06
Fluid Extract of Beef Cibils Co Importers	64.63	16.1[illegible]	11.38	10.25	4.24
Meat Juice Valentine's Meat Juice Co	57.64	10.26	1.77	5.63	6.05
"Rex" Fluid Beef Extract Cudahy Packing Co	55.99	16.99	8.48	7.00	8.21
Vigoral Armour & Co	49.94	15.91	7.0[illegible]	10.75	6.30

* U S Dept of Agriculture Bureau of Chemistry Bull No 114
† The sum of insoluble and coagulable proteins, proteoses and peptones

There are various other meat extracts on the market but the average analyses of the different brands are so nearly alike that the various constituents will not differ markedly from the above figures

Frame Food	7 6?	13 69	0 44	2? 33	54 J6	0 96	Not so rich in minerals as claimed to be
Franco-Swiss Food	4 43	13 00	3 70	46 09	30 86	1 42	Much cane sugar
Horlick's Malted Milk (ready for use) Chittenden	3 06 92 40	16 35 1 15	8 ,8 0 60	67 95 5 38	0 00	3 86 0 29	Holt [?]th ed 1909 Desiccated milk 0 0 wheat flour 26 25 barley malt 23 0 sodium bicarbonate 0 75
Horlick's Malted Food	1 9,	12 06	1 40	81 97	0 00	? 60	J D Henderson
Hovis Babies Food	3 70	7 70	0 90	86 60		1 82	Fully malted
Hovis No 2 Food	? 40	5 0	0 10	90 10		1 70	Starch 7 5 per cent
Imperial Granum	11 0	10 91	0 64	5 73	,0 ?2	1 00	
I and I Food	0	10 30	? 30	80 0		1 40	Mainly starch
John Bull No 1 Food	3 95	51 00	11 87	54 99		32	Maltose ?1 ? lactose ?9 4? dextrin 3 55
John Bull No 2 Food	1 68	11 06	0 68	3, 65	43 50	1 74	Maltose 53 31 dextrose 13? dextrin 5 38 lactose 7 65
Kufeke's Infant Food	8 37	13 ?4	1 69	?3 71	50 ,6	2 ?3	Made in Germany
Lehmann's Vegetable Milk	?4 40	, 0	24 60	41 80		1 50	Made from nuts and can be added to milk
Loeflund's Cream Emulsion	?4 3?	8 23	15 32	49 43		? 60	A thick brown paste made from milk and malted wheat extract
Maltico Food	? 36	16 07	11 80	65 89		3 88	Lancet analysis Composed of milk and
	1 63	1 19	17 19	63 00		2 ?9	malted cereal no starch
Manhu Infant Food	8 80	8 ,0	5 60	75 90		1 00	Desiccated milk and malted cereals much starch
Mellin's Food	5 6?	10 35	0 16	79 5,		4 30	Analysis by makers For modifying milk It is a desiccated malt extract from wheat and barley
Milo Food	3 81	14 34	5 0	58 93	15 30	2 03	Desiccated milk with maltose and dextrins 27 36 and cane sugar ?5 per cent
Moseley's Food	10 84	14 78	1 84	21 76	49 06	1 ?2	Complete conversion during mixing

Most of the analyses except where otherwise stated are those given by the makers

ANALYSES OF INFANTS AND INVALIDS FOODS*

From Sutherland's System of Diet and Dietetics (slightly modified)

Name of Food	Per Cent Water	Per Cent Protein	Per Cent Fat	Carbohydrates: Per Cent Soluble	Carbohydrates: Per Cent Starch	Per Cent Ash	Remarks
Albany Food	8.60	9.50	2.10	73.40		0.40	Much unchanged starch
Allenbury Food No 1	1.82	10.70	16.79	65.51	1.10	4.08	Analysis by Fresenius
	5.70	9.70	14.00	66.85		3.75	
	83.30	1.56	2.30	7.20		0.60	Ready for use Hutchison
Allenbury Food No 2	2.24	10.23	14.94	67.54	1.24	3.81	Analysis by Fresenius A malted meal plus No 1 Food
	3.90	9.20	12.30	72.10		3.50	
Allenbury Food No 3	3.00	10.33	1.05	22.21	62.91	0.60	Analysis by Fresenius Partly malted wheaten flour
	6.50	9.70	1.00	82.80		0.50	
American Swiss Food	5.68	10.54	5.81	45.35	30.00	1.21	Much cane sugar
Anglo Swiss Food	6.50	10.26	4.91	40.43	29.48	2.02	Much cane sugar
Bananina	9.50	4.10	0.40	84.00		2.07	A banana flour
Benger s Food	5.27	12.18	0.91	3.95	76.39	0.96	A milk modifier Much digested in preparing
Carnrick s Soluble Food	5.17	16.69	5.53	28.11	41.50	3.00	Much unchanged starch
Chapman s Whole Flour	8.40	9.40	2.00		79.30	0.90	A whole meal flour
Cheltine Infants Food	7.20	16.20	3.92	71.00		1.83	Contains much starch
Cheltine Maltose Food	4.60	5.30	0.27	87.60		2.25	Fully malted
Coomb s Malted Food	7.90	12.10	2.80	70.80		0.40	Much unaltered starch
Cremalto	22.96	6.40	20.26	44.67		1.79	Cream and malt.
Diastased Farina	8.30	7.60	1.30	81.70		1.10	Carbohydrates said to be made soluble in preparation
Dry Peptonoids soluble	1.50	40.00		51.50		7.00	
Fairchild s Milk Powder	5.54	1.19	0.05	92.00		1.22	Practically milk sugar
Falona	7.00	8.40	3.50	79.90		1.20	Cereals and a fat containing bean

Frame Food	7.69	13.69	0.44	29.33	54.96	0.96	Not so rich in minerals as claimed to be
Franco-Swiss Food	4.43	13.00	3.70	46.09	30.86	1.4	Much cane sugar
Horlick's Malted Milk	3.06	16.35	8.78	67.95	0.00	3.86	Holt 5th ed 1903 Desiccated milk 50.0 wheat flour 26.25 barley malt 23.0 sodium bicarbonate 0.75
(ready for use) Chittenden	92.40	1.15	0.60	5.38		0.49	
Horlick's Malted Food	1.9	12.06	1.40	81.97	0.00	2.60	J D Henderson
Hovis Babies Food	3.40	7.70	0.90	86.60		1.82	Fully malted
Hovis No 2 Food	2.40	5.0	0.10	90.10		1.70	Starch 75 per cent
Imperial Granum	11.50	10.51	0.64	57.3	10.92	1.00	
I and I Food	5.50	10.30	2.30	80.0		1.40	Mainly starch
John Bull No 1 Food	3.98	21.00	11.81	54.93		5.32	Maltose 21.32 lactose 24.42 dextrin 3.5
John Bull No 2 Food	1.68	11.06	0.68	37.65	43.30	1.74	Maltose 23.31 dextrose 1.32 dextrin 5.38 lactose 4.65
Kufeke's Infant Food	8.37	13.94	1.63	23.71	50.76	2.23	Made in Germany
Lehmann's Vegetable Milk	24.40	7.50	24.60	41.80		1.0	Made from nuts and can be added to milk
Loeflund's Cream Emulsion	43.32	9.3	15.32	49.43		2.60	A thick brown paste made from milk and malted wheat extract
Maltico Food	9.36	10.07	11.80	65.89		3.58	Lancet analysis Composed of milk and malted cereals no starch
	1.13	15.19	17.10	63.00		2.99	
Manhu Infant Food	8.80	9.70	5.60	75.00		1.00	Desiccated milk and malted cereal much starch
Mellin's Food	5.62	10.35	0.16	[illegible]		4.30	Analysis by makers For modifying milk It is a desiccated malt extract from wheat and barley
Milo Food	3.91	14.34	5.50	8.93	15.39	2.03	Desiccated milk with maltose and dextrins 2.30 and cane sugar 25 per cent
Mowley's Food	10.94	14.78	1.84	21.76	49.06	1.72	Complete conversion during mixing

Most of the analyses, except where otherwise stated, are those given by the makers

ANALYSES OF INFANTS AND INVALIDS FOODS (*Continued*)

Name of Food	Per Cent Water	Per Cent Protein	Per Cent Fat	Carbohydrates: Per Cent Soluble	Carbohydrates: Per Cent Starch	Per Cent Ash	Remarks
s Food	4 76	15 19	5 10	72 42		2 43	Analysis by Stutzer and Richmond Desiccated milk powdered white of egg wheat flour and lactose
	5 63	14 34	5 80	27 41	44 43	2 39	
Neaves Food	5 03	13 90	1 70	4 71	74 27	1 09	Practically all starch
Nestles Food	3 91	14 34	5 50	58 93	15 39	2 03	A milk modifier
Nichols Food of Health	11 90	7 70	1 70	76 90		1 75	Mainly starch
Nutroa Food	6 80	15 90	10 30	66 00		1 00	Cereals *plus* peanut flour hence the fat
Opmus Food	10 90	9 10	1 00		78 60	0 40	A granulated wheat flour
Ovaltine	3 30	12 01	1 98	76 70	2 57	3 44	A Swiss product
Phosphatine Fallieres	5 85	2 35	1 92	56 68	31 98	1 22	Calcium phosphate cane sugar and starch of potato rice arrow root sago cocoa
Ridges Food	9 23	9 24	0 63	5 19	77 96	0 60	Mainly starch
Robinsons Groats	10 40	11 30	1 60		75 00	1 70	Mainly oats without husk
Robinsons Patent Barley	10 10	5 13	0 97	4 11	77 76	1 93	Ground pearl barley
Savory & Moores Food	5 34	10 79	1 06	27 81	54 09	0 91	*Wheat flour and malt much grape and* cane sugar
	8 34	9 63	0 40	44 83	36 56		
Scotts Oat Flour	5 80	9 70	5 00		78 20	1 30	A fine oat flour Cf Groats
Theinharts Infantina	5 03	16 17	5 00	53 61	16 72	3 47	Desiccated milk diastased cereals lactose and cane sugar
Theinharts Hygiama	4 75	21 22	10 05	49 10	11 33	3 55	More concentrated and a little cocoa added The fat is partly cocoa butter
Triticumina Food	8 60	12 50	2 20	75 70		1 00	Mainly starch
Virol	11 66	6 43	19 72	61 61		0 58	The first analysis is the one given by the makers
	24 04	4 16	10 75	59 25		1 80	
Wells & Richardsons Food	7 76	11 85	1 64	39 00	36 43	2 61	Partly malted Contains much cane sugar and no milk
Wheat Flour	9 02	7 47	1 01	5 60	76 07		

Wheat Flour baked	7 [illegible]8		0 41	14 29	6[illegible] 60		
Worth's Perfect Food	2 40	11 10	2 00	63 50		0 50	
				SUGAR			
Aylesbury Dairy Co's Humanized Milks, No 1*	89 43	1 30	4 00	4 70		0 49	
Aylesbury Dairy Co's Humanized Milks No 2	88 30	2 20	3 60	5 20		0 [illegible]7	
Lagel's Perfected Milk Food	88 04						
Gaertner's Fettmilch		1 08	3 83	[illegible] 82		0 23	
Condensed Whole Milk Sweetened		1 [illegible]0	3 20	6 00		0 35	
	24 06	9 36	11 78	[illegible] 28		2 13	
Condensed Skim Milk	29 93	10 73	0 64	[illegible] 6[illegible]		2 63	
Wells Richardson and Co Lactated Food	6 9	9 6	0 42	29 65	51 38	1 04	
Charles Martin's Cardinal Food	8 18	10 50	0 35	8 35	71 76	0 86	
Likay's Albumenized Food	1 0	7 25	4 [illegible]	[illegible]8 6[illegible]	26 47	0 [illegible]	A milk modifier
Lacto-Globulin	9 85	[illegible]1 44	0 15	11 65		8 30	
Wampole's Milk Food	3 3[illegible]	14 18	7 10	[illegible]1 30		2 64	
Wemalta	8 8[illegible]	19 31	1 3[illegible]	29 70		0 78	
Triangle Food	7 3[illegible]	12 2[illegible]	1 70	3 75	74 [illegible]	0 [illegible]0	
English Milk Food *malted*	[illegible]7[illegible]	8 38	0 [illegible]0	30 30	[illegible]3 9[illegible]	0 99	
Christie's Food	3 70	6 0	3 05	35 6[illegible]	[illegible]0 10	1 00	
Wyeth's Prepared Food	3 00	14 69	1 30	68 30	7 21	3 [illegible]0	
Baby's Own	6 [illegible]	9 63	1 0	22 80	[illegible]9 39	0 58	Requires additions of varying amounts of milk

This and the following analyses taken from Wiley Foods and their Adulteration Philadelphia 1911

TABLE OF SO CALLED MEDICINAL FOODS *

Food	Glycerin and Undetermined Matter	Ash	Per Cent Nitrogenous Matter (N×6.25)	Carbohydrate		Alcohol		Average Recommended Adult Dose per Diem in C.C.	Total Calories in Per Diem Dose †	Cost Per Diem to Supply 1,430 Calories
				Before Inversion	After Inversion	By Volume	By Weight			
Carpanutrine	28.45	0.93	4.28	4.22	5.34	15.5	12.5	60	78.0	$3.39
Liquid peptones	3.63	1.00	4.50	0.00	6.05	22.0	18.0	150	258.6	1.84
Liquid peptonoids	0.23	0.93	4.93	6.56	10.57	17.5	14.0	150	247.5	2.06
Predigested beef	3.40	0.18	2.38	4.29	4.37	19.7	16.0	150	212.0	2.13
Nutrient wine of beef peptone	14.97	0.23	0.64	11.67	15.43	21.5	17.5	100	188.8	1.79
Nutritive liquid peptone	1.02	0.84	1.86	12.58	12.89	23.0	18.8	120	232.1	1.47
Panopeptone	2.60	1.10	6.39	5.76	11.92	18.5	15.0	50	92.3	2.39
Peptonic elixir	3.21	1.55	2.54	11.40	11.46	18.8	16.5	90	157.2	1.72
Tonic beef S & D	12.91	1.61	3.40	1.48	2.36	14.9	12.0	50	55.0	3.25
Liquid peptone	0.44	0.87	1.81	0.55	0.55	14.0	12.0	90	95.4	3.34
Cow's milk (3.8 per cent fat)		0.07	3.50	4.80	4.80			2 000	1 429.6	0.20

* Journal of the American Medical Association, xlix, 1612, 1907.
† Total calories per diem dose include the calories of alcohol in the liquid medicinal foods and the calories of the fat in milk.

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CHAPTER III

PRINCIPLES OF TOXICOLOGY

FRANK P UNDERHILL

Toxicology—Toxicology is the science of poisons In its broadest use it is the science that treats of the origin, nature, properties, effects and detection of poisons, and it includes treatment of poisoning The science falls naturally into two divisions (1) that dealing with the effects of poisons, (2) that relating to the chemical identification and isolation of poisons From these divisions it is readily seen that the first relates more especially to *physiological* action, whereas the latter is primarily concerned with *chemical* reactions

To give a general satisfactory definition of a poison is a somewhat difficult feat Nevertheless various attempts have been made, examples of which follow

Husemann "We define poisons as such inorganic or organic substances as are in part capable of artificial preparation, in part existing ready formed, in the animal or vegetable kingdom, which, without being able to reproduce themselves through the chemical nature of their molecules under certain conditions, change in the healthy organism the form and general relationship of the organic parts, and through annihilation of organs, or destruction of their functions, injure health, or, under certain conditions, destroy life"

Kobert "Poisons are organic or inorganic unorganized substances originating in the organism itself, or introduced into the organism, either artificially prepared, or ready formed in nature, which through their chemical properties, under certain conditions, so influence the organs of living beings that the health of these beings is seriously influenced temporarily or permanently"

Blyth "A substance may be called a poison if it is capable of being taken into any living organism, and causes by its own inherent chemical nature, impairment or destruction of function'

Sollmann "A poison is any substance which, acting directly through its inherent chemic properties and by its ordinary action is capable of destroying life or of seriously endangering health, when it is applied to the body, externally, or in moderate doses (to 50 gm.) internally

CLASSIFICATION OF POISONS

There are at least two ways in which poisons may be classified (1) according to their chemical properties (2) according to their physiological effects From a scientific viewpoint neither system nor a combination is entirely adequate and one must either omit all attempts at classification or else be content to classify poisons from the standpoint of practical utility only A chemical classification follows

1 Acids and alkalis	4 Alkaloids
2 Metallic poisons	5 Volatile organic poisons
3 Gaseous poisons	6 Miscellaneous poisons

The physiological classification recognizes the most prominent symptoms as the basis for division of poison According to this classification, which is that adopted and defined by Sollmann poisons may be divided into three great groups

1 **Irritants**—These produce inflammation, if they are taken by the mouth, there is pain throughout the alimentary canal, vomiting purging delirium, coma So many poisons are to some extent irritant that these symptoms are very commonly present The irritants can be divided into *corrosives* which produce destruction of tissue and *simple irritants* which do not destroy tissue If corrosives are taken by the stomach the vomit is often bloody

2 **Nerve Poisons**—These act on the neuromuscular apparatus and include most of the poisons which are fatal in minute doses They are subdivided into *convulsants* which cause spasms *somnifacients* which cause sleep and coma, and *cardiac poisons* which stop the heart

3 **Blood Poisons**—These poisons alter the hemoglobin or blood corpuscles These include the toxic gases nitrites, etc. Their action is generally characterized by cyanosis

CONDITIONS MODIFYING EFFECTS OF POISONS

The influence of a poison upon the organism is very materially modified by a variety of conditions In general these may be divided into two great classes (1) those relating to the poison itself and the manner of its administration, (2) those relating to the organism itself

Poison and Methods of Administration

Physical State or Form of a Poison—The physical state of a poison has a marked influence in modifying its action Thus a poison is more rapidly absorbed in a gaseous form than in a solid or even a liquid state In order that a substance may act as a poison it must be capable of solution, and absorption by the blood No substance completely insoluble can be regarded as a true poison Barium chlorid, which is readily soluble, must be regarded as extremely toxic, whereas the insoluble barium sulphate is devoid of toxic properties In fact advantage is taken of this in the employment of barium sulphate in X ray photography in diagnosis of gastro intestinal disorders The principle of the form of poison modifying its action is made use of in the treatment of various types of intoxication by means of antidotes, the object aimed at being to change the soluble substance to one insoluble and hence incapable of absorption

In general, dilution of a poison tends to favor rapid absorption and this in turn hastens and intensifies the toxic effect An exception to this rule is seen in the case of those poisons with a corrosive action These have their detrimental influence greatly decreased by dilution Poisons taken into the stomach in the form of a dry powder may not manifest toxic symptoms for hours after administration Usually the larger the dose the more rapid and severe are the effects This, however, is not always true Thus arsenic in large doses may act as an irritant to the stomach, causing vomiting, with prompt ejection of the poison so that few or no toxic symptoms result *On the other hand a very much smaller dose, being devoid* of irritant action on the stomach, allows absorption of the poison with subsequent symptoms which may terminate fatally Again the solvent containing the poison exerts a marked effect upon its action Thus of alcoholic, aqueous or oily solutions, the first is most rapidly absorbed, the last least so and, in consequence, more prompt and emphatic effects are to be expected the more rapid the absorption Hot solutions are usually absorbed more rapidly than cold

Path of Absorption—In general a poison exerts its specific action irrespective of the mode of administration In other words, it makes little difference through which path the poison reaches the circulation The only modifying influence exerted by changing the path of absorption is the time of appearance of symptoms which varies directly with the rate of absorption Thus symptoms appear most rapidly when poisons are injected directly into the blood-stream Intraperitoneal and intramuscular injection stand next in order followed by subcutaneous and intradermal injection

Poisons are less rapidly absorbed when taken by mouth The condi

tion of the stomach greatly modifies the rate of absorption A diseased stomach may markedly delay the absorption of a poison or, on the other hand, prove highly susceptible to an irritant poison Food in the stomach may delay absorption either by retarding the emptying of this organ or by changing temporarily the physical state of the poison Many apparent anomalies of the effects of poisons may be explained in this manner Although it may be generally accepted that the path of absorption modifies the action of a poison only in its time relations and does not alter its specific effect yet there are notable exceptions for in certain instances the mode of administration materially alters the action of the poison This is particularly true of substances resembling proteins, hence capable of alteration by the digestive enzymes Snake venom by mouth is entirely harmless even though highly poisonous when it gains direct entrance to the blood The same is true of the toxic proteins, ricin and abrin, and various bacterial toxins fall into the same class

Poison and Its Relation to the Organism

The most important conditions residing in the organism that modify the action of poisons are (1) age (2) idiosyncrasy (3) habit (4) tolerance, (5) physical state of the individual

Age — As might be assumed the age of an individual distinctly modifies susceptibility to poison Although as a rule the younger the individual the greater the susceptibility there are many notable exceptions Thus, for example children are relatively less susceptible to the action of strychnin belladonna, and calomel Conversely young children are particularly susceptible to the action of opium and its constituents and the same may be said of the other narcotic drugs In old age poisons may react with unusual severity indicating a reduced resistance

Idiosyncrasy —The term idiosyncrasy is applied when an individual exhibits peculiar unusual reactions to certain poisons Lack of knowledge of this peculiar personal susceptibility or tolerance may result in serious disturbances in bodily function or even terminate in death In a given case of poisoning the possibility of this distinctive characteristic should always be taken into consideration Idiosyncrasy may be manifested toward a large number of substances some of which are ordinarily non toxic so that this unusual sensitiveness may be both qualitative and quantitative This feature is brought into prominence in different individuals especially by morphin calomel, arsenic, mercury antipyrin cocain etc

On the other hand in some individuals a drug will induce an effect exactly opposite to that usually produced Thus morphin will cause wakefulness instead of sleep or in larger doses convulsions simulating those

of strychnin Many individuals react with severe symptoms after eating or smelling of a large variety of substances, such as lobsters and other shellfish, honey, various fish, eggs, mutton, strawberries, sewer gas, musk, smell of animals, and odor of flowers.

Habit.—Repeated small doses of a poison generally lessen the effect By gradually increasing the initial small dose of a poison relatively large doses may be taken without evidence of toxic symptoms Habitual morphin users are pertinent examples, very large doses being necessary finally to produce the desired effect Again in certain parts of Europe arsenic eating is notorious, huge quantities being taken daily Whether in the case of morphin the organism develops an ability to oxidize the drug to an unusual degree or whether the intestine acquires a resistance to absorption remains indecisive at present. So far as arsenic is concerned the assumption has been made for many years that there was a gradually increasing resistance to its effects. Very recently, however, it has been shown that the apparent habituation to arsenic may perhaps, in part at least be ascribed to the quality of the arsenic consumed Thus when arsenic made up of small crystals, or powdered, was ingested, much smaller doses were needed to produce toxic effects than when larger particles were introduced From this it would appear that the whole matter may be explained on the basis of solubility of the arsenic, the powder or small crystal being much more readily soluble, hence more rapidly absorbed, than the larger, coarser, crystal

This tolerance to poisons acquired through habit is not absolute, since generally toxic effects and even death may be induced by slightly exceeding the limit of habituation It is this fact that largely explains the death of the habitue of morphin and of other similar poisons Habit, however, cannot be acquired with all drugs, for antimony or mercury, for example, cannot be taken long with impunity even in relatively small doses

Tolerance.—Certain individuals exhibit a very noteworthy resistance to the action of certain poisons This resistance or tolerance is natural not having been acquired by habituation but it is rarely absolute so that it can hardly be regarded as a natural immunity Thus some persons are capable of taking large doses of morphin without any apparent effect The explanation of this peculiarity is not clear In some instances it may be due either to non absorption, rapid elimination, unusual ability to neutralize or destroy the poison or to anatomic peculiarities. In some instances none of these hypotheses seems to hold

Disease.—Pathological conditions in the body may very naturally influence the action and effects of poisons. This modified action may be manifested as an increased susceptibility or the effect may be greatly diminished Those conditions that influence absorption and excretion play a particular role in this respect Renal disease, for example, increases

the susceptibility to arsenic and other drugs In paralysis, strychnin acts less readily In peritonitis delirium tremens and in those states where intense pain exists, the power of morphin is diminished whereas in conditions primarily associated with the nervous system, as in inflammatory conditions of the brain an increased susceptibility may be noted. In insanity with maniacal characteristics and in convulsions, narcotics may be almost without influence Exhaustion tends to increase susceptibility General reduction of vitality from whatever cause usually means a lowered resistance to poisons. On the other hand sleep perhaps owing to lessened functional activity has a tendency to diminish or at least to retard the action of poisons.

FATE OF POISONS

After absorption poisons rapidly leave the blood unless indeed they combine with the constituents of the blood and change its characteristics either temporarily or permanently In general however, poisons remain in the blood for a comparatively short time being excreted through the urine saliva bile sweat and feces. In certain instances more of the poison is eliminated by the feces than by the urine lead, for example Usually, however most of the poison passes by way of the renal path. Poisons are promptly eliminated from the body but are deposited in all the principal organs and tissues In general the liver contains the greater amount of stored poison, the amount deposited in the other organs varying with the type of poison. Gaseous poisons are not deposited but are promptly excreted by the lungs

So far as one may judge a poison deposited in an organ enters into some chemical combination with the cellular constituents and while thus deposited may be regarded as without special detrimental effect. Gradually this combination disrupts and the poison is thrown into the general circulation, injuring sensitive tissues in its passage to the excretory organs which indeed, may suffer injury sufficient to cause death. Usually inorganic poisons are eliminated from the body unchanged the organism being unable to alter them. On the other hand, the natural response of the body is to change or modify the poison prior to elimination. Most of the organic poisons are altered in passage through the body by combination with constituents of the body or by undergoing oxidation hydrolysis or other similar transformation.

SYMPTOMATOLOGY OF POISONS

There are certain outstanding features in poisoning that may be of value to the physician in diagnosis. These symptoms are general and although they do not indicate specific poisons their presence or absence

excludes certain possibilities Special symptoms relating to specific poisons will be considered under individual poisons

Nausea, Vomiting and Purging—When these suddenly appear in a normal individual, it is indicative of the presence of a gastro-intestinal irritant or of the onset of some acute disease Many poisons, especially metals and food poisons, are characterized by initial symptoms of nausea, vomiting and purging If the history of the case agrees with the possibility of poisoning, measures should be taken at once to assist the body in its efforts to rid itself of the noxious substances.

Vasomotor Disturbances—The effects of poisons upon the vasomotor centers is indicated by the fact that many poisons lead to marked changes in the skin The color may be pale or the natural color may be much intensified and urticarial rashes are common Heart action and respiration may be markedly modified in either direction

Cerebral Symptoms—The influence of poisons upon the cerebrum lead to stupor or coma or may produce convulsions, illusions or hallucinations Thus, hallucinations and temporary delusions may follow the use of salicylic acid and strychnin may cause convulsions Stupor and coma may be induced by narcotics or may be due to alcoholism or cerebral hemorrhage

Temperature—The temperature changes in poisoning have not been sufficiently studied to make definite statements concerning them Certain it is that usually changes in temperature must be regarded as secondary effects rather than specific effects of poison Some poisons, like cocain in large doses, may elevate temperature, but usually in poisoning the temperature is either normal or is low, in some instances being as low as 95° F

Pulse—Generally in acute poisoning the pulse is quick and feeble, the extent to which this is true being determined by the degree of shock that may be present Poisons that have a specific action upon the respiratory center may influence the pulse only slightly, if at all, and the pulse may continue with a good tone for some time after respiration has ceased

Respiration—The most common effect of poisons on the respiration manifests itself in dyspnea, which may be due to mechanical obstruction, as in edema of the glottis from local action of a corrosive poison, or to paralysis, as in chronic lead poisoning, or to muscular spasm, as in poisoning with strychnin, or to direct action on the respiratory center, as may be observed with some poisons of bacterial origin Cheyne-Stokes respiration marks the approaching termination of many cases of fatal poisoning

Motor Disturbances—Motor disturbances are so characteristic in certain instances that they lead at once to a correct diagnosis In lead poisoning the wrist-drop is sufficient to arouse suspicion tetanus due to strychnin poisoning is quite peculiar and the mydriasis of atropin poisoning is characteristic Retention of urine occurs with narcotic poisons,

although a general reaction of fatal poisoning is paralysis of sphincters. This fact tends to complicate diagnosis.

The Eye.—Only a few reactions upon the eye are of particular value. Thus contraction of the pupil by morphine and dilatation by atropine are quite characteristic. Yellow vision with santonin and blindness from wood alcohol poisoning are quite specific.

The Ear.—Quinine causes a ringing sensation in the ear; the hearing is more acute under the influence of morphium and salicylic acid causes a buzzing sensation.

Modified Sensations.—Various changes of sensation in the skin, such as anesthesia, hyperesthesia, pins and needles sensation, etc., probably have their origin in some form of poisoning. Neuritis from lead, arsenic and alcohol furnishes examples of abnormalities of sensation induced by intoxication.

Skin Lesions.—The long-continued use of bromides or iodides may result in acnes or fungoid sores. Chronic arsenic poisoning gives rise to the peculiar coloring of the skin called arsenic melanosis, and silver causes the coloration known as argyria. Gangrene may be induced by ergot, and members of the arsphenamine group may be responsible for varied skin eruptions partaking of the nature of urticarial, scarlatinoid and measles-like forms of erythema, together with itching or pruritus of the skin.

DIAGNOSIS OF POISONING

At times the diagnosis of poisoning is exceedingly difficult, since with a few notable exceptions the effects of poisons are not characteristic. It is of course of the utmost importance to be able to make a diagnosis of poisoning so that proper treatment may be instituted.

Suspicion of poisoning arises if an individual who has previously been in apparent good health suddenly manifests notable pathological symptoms which rapidly become intensified. This suspicion is strengthened if the symptoms appear a short time subsequent to the ingestion of some food or drink which may have had a peculiar odor or taste. Suspicion is further firmly established if the symptoms agree closely with those characteristic of a certain group of poisons and if they can be differentiated from disease.

In general, the physician is guided only by symptomatic evidence. This may entirely mislead him since a variety of diseases may cause symptoms simulating those induced by poisons. Thus irritant poisoning may be simulated by gastroenteritis, gastritis and intestinal ulcers, acute indigestion, appendicitis, intestinal obstruction, peritonitis, etc. On the other hand narcotic poisoning may be simulated by epilepsy, apoplexy, cerebral hemorrhage, certain heart diseases, inflammation of the spinal bra[illegible]

spinal system, uremia, etc The symptoms of arsenic poisoning and those of cholera morbus are very similar One may readily mistake apoplexy or uremia for opium poisoning The resemblance between the symptoms of strychnin poisoning and tetanus is very close

In acute poisoning a careful examination will many times enable the physician to make an immediate accurate diagnosis Evidences of corrosion on the lips, tongue, mouth and throat lead one to suspect that a corrosive poison has been taken Chloroform, carbolic acid, potassium cyanid and other odoriferous substances may be detected on the breath and examination of the vomitus and even of the feces may reveal important evidence The urine is of considerable importance in examinations of this kind

The long-continued use of sulphonal or trional gives the urine a red color from the presence of hematoporphyrin which may be identified by the spectroscope Methylene blue imparts a green color to the urine, and antipyrin and fuchsin cause it to assume a red hue In santonin poisoning the fresh urine is normal in color but upon being made alkaline turns bright red The urine turns dark green with phenol and cresol, the color deepening on standing Quinin may cause hemoglobinuria which also results from the inhalation of arseniurated hydrogen Potassium chlorate induces methemoglobin, and blood in the urine may follow the administration of any genito-urinary irritant such as cantharides or turpentine Phosphorus, mercury or lead may give the urine a brown or greenish brown color

Chronic poisoning is even more difficult to diagnose than acute poisoning, because the symptoms are usually not sufficiently definite to arouse the suspicions of the physician

There are no definite rules to establish a diagnosis of poisoning during life except by chemical analysis of some of the excretions of the body, such as urine, feces or vomitus Any drink, food or medicine suspected should be subjected to analysis also In no other way is it possible absolutely to differentiate between the symptoms caused by disease and those induced by poisons

TREATMENT OF POISONING

Each type of poisoning requires specific treatment In many instances, however, the poison taken is unknown and it is therefore essential that general rules of treatment be established These are (1) removal of the poison, (2) administration of antidotes, (3) symptomatic treatment

Removal of Poison —The measures taken will depend upon the site to which the poison was applied If the skin or mucous membranes are concerned, the best agent for removal of the poison is water copiously

applied This application not only dilutes the irritant agent but washes the site free from it If the poison is not freely soluble in water (for instance, carbolic acid), alcohol may be employed Chemical antidotes may be added to wash water—thus for acids soaps or liniment calcis for alkalis lemon juice or vinegar It should be pointed out that strong acids or alkalis should never be used in the treatment of irritant poisons After the site has been thoroughly freed from the toxic agent it should be covered with a bland oil or salve

Most poisons are taken by mouth hence, in treatment, the stomach should be emptied as soon as possible unless indeed sufficient time has elapsed to make this procedure useless On the other hand, it is always a good plan to follow, since the cleansing of the stomach aids greatly in most cases of poisoning There are only a few instances of poisoning where emptying the alimentary tract is contra indicated The most notable of these is in strychnin poisoning and in extensive corrosion of the alimentary canal In emptying the stomach two types of procedure may be followed the administration of emetics and lavage Emetics are most easily given and have the advantage of not causing struggling on the part of the patient If possible however lavage employing the stomach tube, either through the mouth or nose is to be preferred since it cleanses the stomach more thoroughly and also permits the introduction of chemical antidotes Moreover, it is less depressing to the patient and must be employed when poisons have been taken that inhibit the vomiting center—for example chloral or morphin

If emetics are administered repetition should be practiced at intervals of from 15 to 30 minutes if necessary Apomorphin ([illegible] mg [grain 1/10] in 1 per cent solution = [illegible] c c) subcutaneously is very rapid and *effective in its action but has a distinctly depressing influence Its great* advantage lies in the fact that it is the only emetic that can be given hypodermically and it is particularly useful when resistance to treatment is offered Copper sulphate or zinc sulphate are safe and efficient emetics Copper sulphate is perhaps more effective than zinc sulphate but it is also more irritant Both produce a minimum of depression They should not be employed when irritant poisoning is under treatment The dose of zinc sulphate is 2 grams in a glass of water for copper 1/2 gram at once, or three doses of 0 3 gram fifteen minutes apart If vomiting does not occur, the copper salt should be removed by lavage In emergencies a dessertspoonful *of ground mustard stirred in a cup of tepid water may* serve as an efficient emetic At times it is desirable that the entire alimentary tract be cleansed and for this purpose cathartics should be employed They need not be given however until the most acute symptoms have subsided The saline cathartics are to be recommended for this purpose oily cathartics in general should be avoided Enemas are of little value

Administration of Antidotes—An antidote neutralizes the action of a poison either by changing its physical state or its chemical composition, thereby preventing its action or retarding its absorption Since the compounds formed by administration of antidotes may be only slightly less toxic than the original poison or may become poisonous by remaining in the stomach, the giving of antidotes should be combined with lavage or the administration of emetics If lavage is practiced, the antidotes may be added to the wash water, if emetics are used, antidotes may be administered between the intervals of vomiting In general antidotes should be given repeatedly at short intervals In the selection of an antidote care should be exercised that it be as harmless as possible and that the substance resulting from its action is practically inert at least temporarily

Some antidotes, like raw eggs, acacia, milk, boiled starch or flour, which may be given in quantities as desired, act either by combining with the poison to form an insoluble compound—for example, eggs in the case of metals, especially mercury—or by enveloping the poison temporarily in an impenetrable membrane, hence lessening absorption, accomplished in part by delaying the exit from the stomach In the case of irritant poisons these antidotes also tend to allay inflammation

One of the most valuable antidotes is tannin which acts as a precipitating agent This may be employed in the form of very strong hot tea which may be given *ad libitum* Alcohol diminishes its efficiency since the precipitates formed are, for the most part, soluble in alcohol The following antidotes will be found useful against specific poisons *Alkaloidal poisons*—fifteen drops of tincture of iodin in half a glass of water *Barium*—either sodium sulphate (Glauber's salt) or magnesium sulphate (Epsom salt) *Oxalates*—calcium, either in the form of chalk, limewater or whiting *Phosphorus*—copper sulphate or old turpentine *Acids*—weak alkalis, such as chalk baking soda, soap burnt magnesia *Alkalis*—weak acids, such as vinegar or lemon juice *Alkaloids glucosids and phosphorus*—antidotes for these poisons are oxidizing agents which tend to oxidize and hence to nullify the action of the poison Potassium permanganate, about two grains of the crystals in a glass of water, repeatedly given if vomiting occurs or at least a liter of a 0 05 per cent solution In no case should any undissolved crystals be administered For *hydrocyanic acid* poisoning potassium permanganate, hydrogen peroxid or sodium thiosulphate may be employed

In *treatment* of poisoning the hypodermic administration of antidotes is sometimes useful thus for hydrocyanic poisoning sodium thiosulphate may be employed and sodium carbonate may be injected to counteract the action of acids After poisons have had opportunity for absorption attempts to hasten elimination are sometimes made The results have not been highly successful At times, however, some of the measures to be employed are of value It is of course evident that stimu

lation of the renal function will undoubtedly aid in ridding the body of poison In choosing a diuretic it should be remembered that water is the best diuretic known It should be given in large volumes from four to eight liters in twenty four hours if maximum beneficial results are to be realized Hypodermic injection of 0 9 per cent solution of sodium chlorid repeatedly given in liter quantities will also increase urinary excretion Intravenous infusion of the same solution may at times be employed Venesection may be of value in some types of poisoning but the blood drawn (up to a liter) should be replaced immediately by an equal or double volume of isotonic salt solution

Another class of antidotes is the so-called group termed physiological antidotes or physiological antagonists These antidotes do not really nullify the effects of poisons, they merely mask the symptoms produced They are employed only against absorbed poisons and tend to combat the symptoms produced by arousing the opposite action In this way they sometimes are of value in carrying the patient over a critical period and aid in conserving life Some of the physiological antagonisms are atropin to pilocarpin caffein to morphin, strychnin to nicotin, chloral to strychnin atropin to morphin, chloroform to strychnin etc

Symptomatic Treatment —In most cases of poisoning, symptoms produced by the absorbed poison are the most dangerous and these should receive attention from the beginning of the treatment One of the first functions to fail is the respiration Treatment to sustain respiration should not be delayed until respiration has actually ceased but reflex stimulation of the respiratory center should be begun as soon as any evidence is given of the weakening of respiration For this purpose use may be made of inhalation of ammonia water or smelling salts or administration of aromatic spirits of ammonia (half a teaspoonful in a glass of water), whipping with wet towels mustard plasters etc. Or if desired agents to act directly upon the respiration may be employed such as hot coffee, atropin (0 001 gram) or strychnin (0 002 gram) If none of these measures is effectual artificial respiration should be practiced in a manner to avoid injury to the lungs

In certain types of asphyxiating gas such as CO oxygen inhalation alone or inhalation of oxygen with small percentages of CO_2 may be of benefit

In attempting to stimulate the poisoned heart intravenous infusion of isotonic salt solution alone or with the addition of epinephrin (1 100 000) may be of value Dilatation of the heart may be relieved by venesection The patient should be kept quietly in bed cooling prevented by application of heat pain controlled by anodynes convulsions counteracted by chloroform and coma combated by stimulants such as coffee or atropin

For poisoning cases the following suggestion by Sollmann is highly recommended

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strated even on microscopic examination, for it affords an opportunity to determine whether death can be ascribed to natural causes In the event that the organs and tissues reveal no pathological aspects, suspicion of poisoning is even more firmly established

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'**Antidotes for First Aid**—Every physician should keep the following antidotes together in a special satchel ('Antidote Bag') so that they can be readily transported The dose should be written on each container Amyl nitrite pearls, apormorphin tablets, 2 mg, atropin tablets, 1 mg, caffein sodium benzoate, chloroform, cocain hydrochlorid tablets, 0 03 gm, tincture of iodin, copper sulphate, powdered, lime water, magnesia, calcined, potassium permanganate, 1 per cent solution (to be diluted twenty times), sodium sulphate, spiritus ammoniæ aromaticus, strychnin sulphate tablets, 2 mg, whisky, also a hypodermic syringe in good order, and a stomach tube with funnel The following should be demanded at the house of the patient boiled water, coffee (strong, hot, and black), eggs, hot water bags, milk, mustard, salad oil, salt, soap, starch, boiled, tea, vinegar"

In criminal cases of poisoning the physician should carefully note and record the symptoms observed and take possession of any suspected substances such as medicine, food, drink, and he should also preserve vomitus, urine and feces In the event of an autopsy where a chemical analysis is anticipated it is desirable that the chemist be present In this way much more satisfactory correlation may be obtained in tracing the origin of the organs than if they are delivered to the chemist by the physician Moreover, the chemist will also be able to testify that the vessels containing the organs and tissues are chemically clean

In many instances it is deemed sufficient to examine the stomach and intestines for the presence of poisons This, however, is not adequate practice In addition to the tissues mentioned, portions of all the principal organs, including the brain, cord and urine of bladder, should be secured, especially if the nature of the poison is unknown In the event that a quantitative estimation of the poison is called for, the total weights of the organs selected should be determined The various organs and tissues should be preserved in separate vessels without addition of antiseptics and the chemical examination should be begun as soon as possible after the autopsy, although in most instances poisons do not rapidly disappear from the body after death On the other hand, poisons that are gaseous or readily volatilized may disappear very rapidly after death

The autopsy itself may not reveal the cause of death Indeed, in most cases of death by poisoning, the autopsy fails to show the cause of death In this event chemical examination is relied upon to furnish the proof At times even this fails, for the poison may have been largely eliminated and exist in any particular organ in quantities too small to be detected by present-day methods or it may be a poison for which there is no specific chemical test. In most instances, however, the chemical examination may be relied upon to give the desired information

The autopsy is of great value in suspected poison cases, although no evidences of poisonous action on the organs and tissues can be demon

strated even on microscopic examination, for it affords an opportunity to determine whether death can be ascribed to natural causes In the event that the organs and tissues reveal no pathological aspects suspicion of poisoning is even more firmly established

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CHAPTER IV

THE PRINCIPLES OF MEDICAL CLIMATOLOGY

Henry Sewall

Scope of the Subject.—In its physical aspects, climate is determined by the facts of meteorology, or science of the atmosphere, and this in turn is inseparable from physiography, which pertains to the structure of the earth, and the distribution of its various features. According to Hann, 'by climate we mean the sum total of the meteorological phenomena that characterize the average condition of the atmosphere at any one place on the earth's surface. That which we call weather is only one phase in the succession of phenomena whose complete cycle, recurring with greater or less uniformity, every year, constitutes the climate of any locality. *Climate* is the sum total of the *weather* as usually experienced during a longer or shorter period of time at any given season.'

But in ordinary usage the word *climate* inevitably suggests a relation between the physical conditions of earth, air, and water to be found in any place, and the sensations and activities of man.

The vital relations of the physical elements of climate are well illustrated in the distribution of the various forms of animal and plant life. Man himself, through his ability to make fire and clothing and to command food, has been able to adapt himself to the widest extremes of climatic conditions.

When a plant or an animal flourishes in a given locality, its organs and functions are said to be adapted to the conditions there found. To a great extent such forms, or their descendants, may be brought, by gradual change, to live in a totally different environment.

This adaptability of living beings to widely different external conditions, through which forces which were once destructive become again conservative of life, depends upon a *physiological reaction* of the living organism to the influences acting on it. The physiological reaction of protoplasm to internal and external agencies determines the nature, the distribution, and the evolution of all forms of life.

As we view the races of men in their habitats, from the poles to the equator, it is obvious that the differences between them are more or less dependent upon adjustment to their various environments. This ad

justment involves not only the externals of clothing, the struggle for food and the general habits of life, but strikes into social and moral relations and results in anatomical differences at least of form and color What may be called *physiological climatology* seeks to determine what are the vital reactions especially evoked in various climates what functions of the body are specifically stimulated or soothed and what may be the effect, on the organism as a whole of any definite climate Human history is still too brief to enable us to certify whether limitations of physiological adaptation rigidly restrict the geographical distribution of a given race of men without fundamental change in their ethnographic characters Caucasian peoples are rapidly claiming the whole earth, and it is a matter of urgent moment to learn the natural adaptations they must acquire to conserve best their preeminence under new conditions

Until recently the problem of physiologic adaptation to climate has been inextricably confused with the incidental effects on man of the climatic distribution of pathogenic microorganisms While the white man has acquired a certain degree of immunity against the infections common to temperate zones he is so susceptible to the disease provoking organisms teeming in the tropics that no fair opportunity has been allowed for his normal development in such regions The migrations of the white race have been limited by the geographical distribution of pathogenic protozoa, and of certain insects which serve as their intermediate hosts

The extraordinary demonstration in Cuba the Philippines and the Canal Zone that the infections which had threatened the lives of strangers in those regions are rigidly under control of Sanitary Art for the first time gives the immigrant opportunity to adjust himself to tropical conditions Enough has already been learned through the health reports from such localities to make it probable that morbidity and mortality among healthy adults at least are not essentially increased or accelerated by residence in tropical climates As Clemow says "Many—almost the majority—of the ordinary infective fevers are most prevalent in the cool and not the warm season of the year" In temperate climates the transmission of the most important infections depends more or less upon the intimacy of contact between the sick and the well and the application of hygiene involves a regulation of sociologic relations

While these views of climatology have a broad bearing on ethnogeny and eugenics interest is especially concerned with the influence of climate upon the sick man or as an environment antagonizing the inception of disease As the welfare of the human being in his conflict with disease depends in general on physiological reactions which lead to development of compensations adaptations or antidotes within the organism it is obvious that the study of *medical* no less than *physiological climatology* has to do with vital reactions to climatic conditions

The first step should afford a comprehensive view of the physical elements of climate and the results of their combinations in actual climates Then should follow an account of observations and experiments upon the physiological reactions of normal beings to the physical conditions of climate, singly and combined Finally, consideration should be given to the natural distribution of diseases and to the effect of climates and climatic factors in conserving or antagonizing the forces of the human organism in its struggle with disease Medical climatology must automatically shrink with the development of specific therapeutics and preventive medicine

It is important to realize that, while man moves and breathes in a *gaseous atmosphere, the protoplasmic units of which he is constructed* are bathed in lymph which forms his true internal environment, the constancy of whose composition is far more important to normal life than is that of the circumambient air

When the normal alkalinity of the blood suffers a reduction there is immediate physiological reaction and the disturbance may be so profound as to destroy life This condition of "acidosis" is the result of obscure and probably diverse causes It is desired here to express the suspicion that the physiological relations of climate are largely achieved through a modification of metabolism, one of the results of which is an alteration of the acid alkali balance of the blood Similar results may follow stimuli as widely different as diet and psychic emotion It is quite possible that physiological effects which we attribute to climatic change are often directly mediated through such plasma changes as have been indicated

METEOROLOGICAL CLIMATOLOGY

Climates owe their characters to the quantitative relations of certain physical elements the principal of which are (1) temperature, (2) atmospheric moisture or humidity, (3) atmospheric movements or winds, (4) soil, (5) water, (6) light, (7) electricity As will shortly be seen, various other relations are of salient importance These are latitude, the geographical distribution of land and water, ocean currents, the existence of mountain chains and elevation above the sea insolation, and atmospheric composition, including impurities Various factors of climate may have a different relative importance, according as they are viewed as agents affecting the physical conditions of the earth, or the welfare of forms of life upon it *The biologic importance of direct insolation* and of winds far outweighs the physical influence of these factors

Temperature—Probably the most important single factor of climate is *temperature* With the sun vertical over the equator, a beam of energy

which covers a unit area of the earth would be distributed over a progressively larger surface if deflected obliquely toward the poles It is said that the amount of solar energy falling upon a given area along any meridian at midday varies approximately as the cosine of the latitude Less heat therefore, descends upon a given area of the earth with increasing obliquity of the rays Moreover as the shell of atmosphere enveloping the earth has through its watery content power of absorbing heat it is obvious that oblique rays, which pursue a longer atmospheric path are robbed of their heating power Three conditions determine the insolation or amount of solar energy received at any place

1 The obliquity of the rays according to which less heat falls upon a given surface obliquity increases with latitude

2 The relative length of day and night The ratio of day to night increases with latitude in summer As pointed out by W L Moore the rapidly increasing length of the day toward the poles during summer soon more than compensates for the decreasing angle at which the solar rays strike the earth so that during summer the insolation is actually more abundant at the poles than at the equator

3 The absorption of solar energy by the air In dust free air the absorption of heat depends upon the presence of contained watery vapor carbon dioxid and ozone There is reason to believe that in the upper atmosphere above eleven kilometers the amount of ozone is appreciable and constant With increasing obliquity of the rays more air is traversed and more heat absorbed Watery vapor and carbon dioxid have a specific absorptive power for the longer rays of the spectrum

INTENSITY OF INSOLATION AT DIFFERENT SOLAR ALTITUDES (MOORE)

Altitude of the Sun in Degrees	Relative Length of the Path of Rays through the Atmosphere	Intensity of Insolation Surface Perpendicular to the Ray	Intensity of Insolation Horizontal Surface
0	44 70	0 00	0 00
5	10 80	0 15	0 01
10	5 70	0 31	0 05
20	2 92	0 51	0 17
30	2 00	0 62	0 31
40	1 56	0 68	0 44
50	1 31	0 72	0 55
60	1 15	0 75	0 65
70	1 06	0 76	0 72
80	1 02	0 77	0 76
90	1 00	0 78	0 78

Although the earth is actually nearer to the sun in the winter of the northern hemisphere than in the summer the greater relative obliquity of the rays during the former season is the chief cause of its cold In the

matologic and physiologic relations The atmosphere always contains more or less watery vapor The amount of vapor which it can contain without condensation into liquid particles increases with the temperature A definite weight of water when evaporated will saturate a definite cubic space at a definite temperature The amount of vapor thus sustained is nearly indifferent to the gases already present If the temperature of a saturated space be lowered, part of the vapor will be condensed If the temperature rises, more vapor can be sustained The following table represents the maximal quantity of water that can exist as vapor in a cubic foot of space at various temperatures

Aqueous Vapor in a Cubic Foot at Various Temperatures

Temperature	Number of Grains of Aqueous Vapor in a Cubic Foot	Temperature	Number of Grains of Aqueous Vapor in a Cubic Foot
100 F	19.8	30 F	1.9
90 F	14.8	20 F	1.2
80 F	10.9	10 F	0.8
70 F	8.0	0 F	0.[illegible]
60 F	5.7	−10 F	0.3
50 F	4.1	−20 F	0.2
40 F	2.8		

The actual amount of vapor contained in a given volume determines the *absolute humidity* This, as just seen, has a maximum which increases with the temperature The ratio of the amount of vapor actually present to that necessary to saturate the space at a given temperature is known as the *relative humidity*

Thus, if it requires ten grains of vapor to saturate a cubic foot of air at a given temperature, and but seven grains are actually present, the relative humidity is 70 per cent. The amount of vapor remaining the same, the relative humidity falls as the temperature rises, and vice versa These relations gain their importance from the fact that the rate and amount of evaporation from a surface depend largely upon the capacity of the air for absorbing moisture

The lower the relative humidity the more powerful is the evaporating force A knowledge of the absolute humidity of the air is sufficient for the purposes of the physicist, but the relative humidity expresses conditions of more physiological importance Air at high temperatures can be "very dry," and still contain more moisture than cool air which is "very damp"

The atmospheric humidity is determined by the *psychrometer* which consists of a pair of thermometers, the bulb of one of which is covered with muslin moistened with water The mercury of the "wet bulb" instrument stands at a lower level than that of the "dry bulb" to an extent

determined by the rate of evaporation from the moist muslin. The readings of the wet bulb are thought to represent the "sensible" or physiological temperatures more nearly than those of the dry bulb. The action of wind greatly accelerates evaporation; a low degree of humidity which *might be comfortable in the still air of a room would be disagreeable in* the moving air of the open. Some observers prefer to consider, not the relative humidity, but its complement, the "saturation deficit," which is the percentage of vapor which the air lacks for its saturation. The drying power of the air is determined by the percentage of watery vapor which is needed to saturate it. Thus at 30° C. (86° F.), with relative humidity 80 per cent, the amount of water that can still be taken up is about the same as when the air temperature is 10° C. (50° F.) and its relative humidity only 36 per cent.

In changing from the liquid to the gaseous form, water absorbs a great amount of heat, rendering it latent and insensible to the thermometer. This heat of vaporization is taken from the air and especially the sur*face, from which evaporation occurs. When the vapor is condensed by* falling temperature, its latent heat is returned to the air, and the cooling by that extent is checked. The "dew point" is the temperature at which *vapor is condensed upon surfaces chilled by radiation below the saturation* temperature of the air.

The absolute humidity of any region depends, in general, upon the extent of water surface, including the moisture of vegetation, exposed to evaporation. It varies but slowly from time to time. The relative humidity, on the other hand, rises and falls rapidly, inversely with the temperature. It is higher in the morning than in the afternoon. The capacity of the air to hold moisture rises with the temperature. The rate of evaporation decreases with the rise of relative humidity, but increases with the temperature of the moist surface and especially with wind movement which removes the humid layer of air in contact with it. Evaporation is increased in high altitudes both because of the lowered barometric pressure and by reason of the low per cent of moisture in the air. As the amount of water which the air can hold depends upon the temperature of the latter, and as the temperature rapidly diminishes with altitude, it follows that most of the vapor is confined to the lower layers of the atmosphere. About half the watery vapor lies below the level of 6,500 feet, and nine-tenths below 21,300 feet of altitude (Hann). The intricate and profound relations of heat and moisture to physiological functions will be dwelt upon in a subsequent section. They largely regulate both the metabolism of the body and its sense of well being.

Rain is due to the condensation of the vapor of the atmosphere when it is chilled to the dew point. The tiny droplets thus formed coalesce to a greater or less extent before they fall. *Solid particles suspended in* the air under ordinary conditions serve as condensation centers for the

rain drops It is said that in saturated, dust free air condensation may begin on suspended ions

Rain washes and purifies the air and becomes of great hygienic importance to the atmospheres of large cities Rain is more abundant in warm than in cold countries, and in regions where large surfaces of water are exposed to evaporation, provided the conditions for sudden chilling in the upper air are present, as on windward shores and in hill districts Moisture laden air, on striking a range of mountains, is deflected upward, and, being cooled, is apt to precipitate its moisture as rain on the windward side

Winds—The chief cause of wind is an unequal heating of the air Air expands or contracts by 1/491 of its volume for every degree Fahrenheit of rising or falling temperature Warm air is specifically lighter than cold air, and when masses of air at different temperatures are contiguous, they move down or up with velocities determined by the difference of densities The foundation of wind on temperature is simple in explanation, but fundamental in importance

A patch of sandy soil gets hotter under the sun than a surrounding surface of clay The superior radiation from the sand heats the air just above it, and the heated air rises as if in a chimney, the cooler surrounding air continually pressing in and replacing it at the surface, to be warmed in turn The column of expanded air, on reaching a greater or less height, flows over upon the surrounding bed of cooler atmosphere Wind is the movement necessary to the restoration of equilibrium of density throughout the atmosphere As aqueous vapor is specifically lighter than either oxygen or nitrogen, a given volume of moist air is lighter than that of dry air at the same pressure and temperature Humidity is, therefore, a cause of winds Winds are classified as permanent, periodic, and non periodic. 'To the permanent winds belong the trade winds, the antitrades, and the prevailing westerlies of high latitudes, to the periodic winds belong monsoons, land and sea breezes, mountain and valley breezes to the non periodic winds belong the high winds that accompany cyclones and anticyclones, including the hurricane of the West Indies, the typhoon of the China Seas, the simoom of Arabia and Africa, the sirocco of Italy, the fohn winds of the Alps, the chinook winds of the northwestern part of the United States, the mistral of Europe, the Texas northers, the blizzards and the hot winds of our western plains, tornadoes, the thunderstorm gusts, whirlwinds, and many others' In this article only the general features of the subjects can be discussed

Warmed air rises as it expands and cooled air descends as it contracts The contrast between currents of different temperatures is particularly obvious where they are confined, as among the slopes and valleys of a mountainous region Uniform terrestrial wind movements largely depend upon the heating of the air in equatorial regions. A

vertical motion is thus given to the medium and the air being heaped up in the higher altitudes, flows off north and south to about latitude 30°, where, having become denser than the supporting medium it descends to a greater or less extent in a vertical direction Air currents on the surface of the earth have, of course the reverse direction to those above The dense air of the polar circles flows equatorward until it meets the surface currents moving poleward when it ascends vertically to be distributed again according to the relative densities As Phillips puts it The final result would be surface winds on the equatorial sides of latitude 30 toward the equator and on the polar sides toward the poles surface winds within the polar circles toward the equator regions of variable winds and calms at the equator latitude 30 and the polar circles The circulation however would still be along meridians These ideal relations are somewhat changed by the axial rotation of the earth As the actual velocity of rotation on a meridian increases from pole to equator a mass of air moving southward is in the northern hemisphere left behind its appropriate meridian and becomes directed southwest The result of this motion is seen in a deflection of meridianal currents so that in the northern hemisphere north winds become northeast and south winds become southwest in direction In the southern hemisphere the deflections would be complementary

The so-called *trade winds* of lower middle latitudes have their explanation in such rotational deflections of meridianal currents Such relations hold well over the oceans but the modification of temperature conditions over continental areas and especially the obstructive and cooling influence of mountain ranges complicate the actual wind movements

The orderly connection between temperature and wind is familiar in the daily land and sea breezes on the coast line of any large body of water The specific heat of land and water being about as 1 to 4, the land is rapidly heated in the day time and the air expanding above it flows seaward in the upper regions The cooler air over the water takes the reverse direction along the surface thus giving rise to the tempering sea breeze of a summer s day At night the land rapidly loses heat by radiation and the air above it becomes more condensed than that above the water The result is a nocturnal land breeze which lasts until temperature equilibrium is again reached

Cyclones and Anticyclones—During summer the excessive heating of continental areas leads to the generation of upward air currents many hundreds of miles in diameter The lowest barometric pressure under such an expanse of upward motion is about at its center The denser surrounding atmosphere flows in from all directions along the surface toward the point of lowest pressure The actual direction of wind movement, however is not radial toward the 'low center, but, following the law of meridianal motions, the currents in the northern hemisphere take

rain drops It is said that in saturated, dust free air condensation may begin on suspended ions

Rain washes and purifies the air and becomes of great hygienic importance to the atmospheres of large cities Rain is more abundant in warm than in cold countries, and in regions where large surfaces of water are exposed to evaporation provided the conditions for sudden chilling in the upper air are present, as on windward shores and in hill districts Moisture laden air on striking a range of mountains, is deflected upward, and, being cooled, is apt to precipitate its moisture as rain on the windward side

Winds—The chief cause of wind is an unequal heating of the air Air expands or contracts by 1/491 of its volume for every degree Fahrenheit of rising or falling temperature Warm air is specifically lighter than cold air, and when masses of air at different temperatures are contiguous, they move down or up with velocities determined by the difference of densities The foundation of wind on temperature is simple in explanation, but fundamental in importance

A patch of sandy soil gets hotter under the sun than a surrounding surface of clay The superior radiation from the sand heats the air just above it, and the heated air rises as if in a chimney, the cooler surrounding air continually pressing in and replacing it at the surface, to be warmed in turn The column of expanded air, on reaching a greater or less height, flows over upon the surrounding bed of cooler atmosphere Wind is the movement necessary to the restoration of equilibrium of density throughout the atmosphere As aqueous vapor is specifically lighter than either oxygen or nitrogen, a given volume of moist air is lighter than that of dry air at the same pressure and temperature Humidity is, therefore, a cause of winds Winds are classified as permanent, periodic and non periodic. "To the permanent winds belong the trade winds the antitrades, and the prevailing westerlies of high latitudes, to the periodic winds belong monsoons, land and sea breezes, mountain and valley breezes, to the non periodic winds belong the high winds that accompany cyclones and anticyclones including the hurricane of the West Indies, the typhoon of the China Seas, the simoom of Arabia and Africa, *the sirocco of Italy, the fohn winds of the Alps, the chinook* winds of the northwestern part of the United States, the mistral of Europe, the Texas northers, the blizzards, and the hot winds of our western plains, *tornadoes the thunderstorm gusts, whirlwinds, and many others*" In this article only the general features of the subjects can be discussed

Warmed air rises as it expands and cooled air descends as it contracts The contrast between currents of different temperatures is particularly obvious where they are confined, as among the slopes and valleys of a mountainous region Uniform terrestrial wind movements largely depend upon the heating of the air in equatorial regions A

vertical motion is thus given to the medium and the air being heaped up in the higher altitudes flows off north and south to about latitude 30°, where having become denser than the supporting medium it descends to a greater or less extent in a vertical direction. Air currents on the surface of the earth have, of course, the reverse direction to those above. The dense air of the polar circles flows equatorward until it meets the surface currents moving poleward, when it ascends vertically to be distributed again according to the relative densities. As Phillips puts it: "The final result would be surface winds on the equatorial sides of latitude 30° toward the equator and on the polar sides toward the poles; surface winds within the polar circles toward the equator; regions of variable winds and calms at the equator, latitude 30°, and the polar circles. The circulation however would still be along meridians." These ideal relations are somewhat changed by the axial rotation of the earth. As the actual velocity of rotation on a meridian increases from pole to equator, a mass of air moving southward is, in the northern hemisphere, left behind its appropriate meridian and becomes directed southwest. The result of this motion is seen in a deflection of meridianal currents so that in the northern hemisphere north winds become northeast, and south winds become southwest. In the southern hemisphere the deflections would be complementary.

The so-called *trade winds* of lower middle latitudes have their explanation in such rotational deflections of meridianal currents. Such relations hold well over the oceans, but the modification of temperature conditions over continental areas and especially the obstructive and cooling influence of mountain ranges complicate the actual wind movements.

The orderly connection between temperature and wind is familiar in the daily land and sea breezes on the coast line of any large body of water. The specific heat of land and water being about as 1 to 4, the land is rapidly heated in the day time and the air expanding above it flows seaward in the upper regions. The cooler air over the water takes the reverse direction along the surface, thus giving rise to the tempering sea breeze of a summer's day. At night the land rapidly loses heat by radiation and the air above it becomes more condensed than that above the water. The result is a nocturnal land breeze which lasts until temperature equilibrium is again reached.

Cyclones and Anticyclones.—During summer the excessive heating of continental areas leads to the generation of upward air currents many hundreds of miles in diameter. The lowest barometric pressure under such an expanse of upward motion is about at its center. The denser surrounding atmosphere flows in from all directions along the surface toward the point of lowest pressure. The actual direction of wind movement, however, is not radial toward the low center but, following the law of meridianal motions, the currents in the northern hemisphere take

a circular direction opposite to that of the hands of a watch Such a system of wind movement is known in meteorology as a *cyclone* Conversely, when a column of air becomes heavier than the atmosphere in general, as commonly happens over continents in winter, the denser air moves vertically downward and passes outward along the surface from this center of high barometric pressure For obvious reasons, the direction of wind motion in such a case is, in the northern hemisphere, like that of the hands of a watch Such a system of wind movement is known as an *anticyclone* The physiological effect of the cold, dry, pure air thus brought to the surface is one of invigoration The reader is referred again to the comprehensive work of Moore for a graphic account of the meteorological bearings of this subject Winds are of very great importance in medical climatology They may furnish in turn the most grateful relief from the depressing effects of heat and moisture, or render an otherwise enjoyable climate unbearably rigorous

Altitude—The factors of climate are more or less modified with elevation above sea level The weight of the atmosphere and, therefore, the barometric pressure decrease progressively in a vertical direction from the surface of the earth When the barometer reading at sea level is 29 97 inches Hg, at an elevation of 5,000 feet it is about 24 97 inches, and at 10 000 feet 20 39 inches The rate of fall decreases progressively In the first 1,000 feet of elevation the pressure is lowered by 1 15 inches Hg, in the tenth 1,000 feet by only 0 77 inch Hg According to Boyle's law, the volume of a gas varies inversely with the pressure, the temperature remaining the same Therefore, the atmosphere is progressively rarefied with increasing altitude, the proportion of its constituents remains the same At an elevation of about 3 5 miles, or 18,480 feet, the pressure is reduced to about half that of sea level Permanent human habitations occur at altitudes approximating this (over 16,000 feet in Thibet and Bolivia—Hann) As the weight compressing the air decreases with elevation, air expands, and in expanding absorbs from the surroundings heat which becomes latent because doing the work of expansion. On returning to a lower level this latent heat is given off again when the air reaches its original volume Dry air falls in temperature about 1° F for every 183 feet of elevation When the air is moist this relation is disturbed by the latent heat set free from condensing watery vapor Over the equator continuous snows are found on mountains at an altitude of 18 000 feet The snow level north and south descends with increasing latitude and varies with the season. Mountain tops are said to be cooler than the free air about them, though the rate of temperature decline is less on mountain slopes than in the free air, and over elevated table lands the temperature decrease is much more gradual The usefulness of these facts depends upon their adaptation to surface conditions at various elevations

Watery vapor follows the law of expanding gases and decreases per volume of air with ascent, moreover, the amount held in solution is reduced by the lowered temperature (see table page 174)

Solid particles, which form an adventitious but constant constituent of the atmosphere at low levels, decrease with ascent above the surface The air upon high mountain slopes has been found free from dust and bacteria The result of these conditions has more physiological than physical value Vegetation is sharply limited, owing to the falling temperature on the slopes of high mountains as shown by the 'timber line' which is higher on southern than on northern exposures

Pure, dry air is nearly diathermanous Solid particles carbonic acid and especially water in suspension are the atmospheric elements chiefly capable of absorbing heat We therefore find that their reduction in elevated regions is manifested by increased intensity of insolation A surface capable of absorbing heat becomes excessively warm under the sun s rays but, the air being cold, a thermometer placed in the shade shows a low degree of temperature The heat absorbing constituents of the atmosphere also operate specifically upon the less refrangible rays of the spectrum Therefore, solar heat and light are not only more intense in the clear air of high altitudes, but the proportion of chemical rays is greater than at sea level

The science of aerology has achieved such rapid development that investigators are more and more confidently using its data in the explanation of puzzling records of geologic events such as the glacial epochs

While meteorology may be considered a parent of climatology their interdependence must be worked out empirically for every complex of conditions

The present status of our knowledge is well set forth in the recent monograph of Humphreys He writes 'The atmosphere is divisible into the stratosphere and the trophosphere or the isothermal region (with a temperature of about minus 55 C) and the convective region or in other words that region in middle latitudes at and beyond about eleven kilometers above sea level where because of freedom from vertical convection ordinary clouds never form and that other or turbulent stormy region below this level which is frequently swept by clouds and washed by snow and rain

Soil—The nature of the soil found in any locality is an important climatic factor Soils differ greatly in their capacity for absorbing and radiating heat and for holding water Estimating the capacity for heat absorption and radiation of sandy limestone at 100 that of pure sand is 96 that of various clays varies from 67 to 77 while that of humus is only 49 It has been found that a layer of sand half an inch or more thick on marshy ground so increases its absorptive power that the radiation at night suffices to prevent the freezing of crops that would otherwise

suffer. The greatest range of temperature is found where the land has the greatest power of absorption and radiation, as over deserts. The character of the soil has especial importance in its relation to the absorption and retention of water. Sand absorbs water most readily, but allows it to percolate rapidly. Therefore, a sandy surface quickly dries after a heavy rain, unless underlaid by an impervious layer. Clay absorbs water with difficulty, and gives it up slowly. Humus has extraordinary capacity for absorbing water, which it takes up slowly, but retains strongly. Damp soils are those which retain or prevent the percolation of water. Cultivation of the ground greatly enhances its capacity to store water. The atmospheric humidity varies with the moisture in the soil, and the temperature relations of the air approach in equal degree those found over water surfaces. The reflecting powers of the ground covering are of physiological moment, as witnessed in the glare from *sandy deserts* on the one hand, or mountain snow fields on the other.

Electricity.—Electricity is a climatic factor of unknown value. It is said that the atmosphere is usually positively electrified with regard to the earth, and that the open *air is positive to that within dwellings*. *During* rain storms the air charge is said to become negative. In the dry air of elevated regions the house dweller is often painfully reminded of his electric potential by the shock that follows his touch of a grounded conductor.

There may be truth in the popular *conception that ozone* has important climatologic relations. It is a powerful oxidizing and purifying agent. It is formed from oxygen under the influence of electric discharges produced by many and various meteorologic and telluric conditions, or by the action of ultraviolet ray. *In general*, *its presence* indicates the absence of organic pollution, and is associated with a bracing physiological effect of the air.

In the presence of moisture and at ordinary temperatures it quickly reverts to ordinary oxygen, but at very high altitudes, where the temperature is about minus 55° C., it is supposed to be formed under ultraviolet radiation from the sun and its condition is far more stable.

Composition of the Atmosphere.—The composition of the free air in different places is remarkably uniform. This is given for pure dry air by Moore in the following:

COMPOSITION OF THE ATMOSPHERE

	By Volume	By Weight
Nitrogen	78.04	75.46
Oxygen	20.99	23.19
Argon	0.94	1.30
Carbon dioxid	0.03	0.05
	100.00	100.00

Other gases, such as krypton neon, etc, which occur in small amounts are without known effect A small trace of ammonia important to plant life, is said to be normally present A most important and variable constituent is watery vapor which ranges in amount from 3 per cent of volume in the dampest regions to a vanishing proportion in the driest. The percentage of the different components of the atmosphere with the exception of the watery vapor, is practically unchanged by altitude

Barometric Pressure—This is the sum of the partial pressures of all the gases in the atmosphere While the total pressure is due to and measures the total weight of the air-cone supporting the mercurial column the partial pressures of the various components of the air do not exactly measure their relative weights Equality between partial pressures and weights would hold if the percentages of the gases present remained constant throughout the atmospheres but when the percentage of any substance decreases with elevation, the pressure it exerts is correspondingly greater than its own weight Thus the pressure of water vapor at the surface of the earth is about six times its weight or sixfold what it would be if the gases were not present"

The atmospheric pressure at sea level in fair weather is usually represented by a mercurial column 760 millimeters about 30 inches high The pressure decreases regularly with altitude but its decline is affected by latitude, temperature and humidity The barometric fall for equal ascents becomes slightly less with increasing altitude Roughly estimated the barometer falls 1 mm for every 12 meters ascent, or 1 inch for each 328 yards above sea level

Dust and Impurities in the Atmosphere—The hygienic relations of atmospheric purity will be referred to later Except in the uninhabited regions of high altitudes, and to a degree over the oceans dust particles including microorganisms are constantly suspended in the air The air of large cities invariably shows hundreds of thousands of dust motes to the cubic centimeter, that of the village or town thousands and that of the open country at least hundreds" Light striking upon the suspended dust particles is scattered in all directions They are the chief elements in the diffusion of daylight In dust free air only objects would be visible which were illuminated by the direct rays from the sun or those reflected from visible surfaces Tyndall found in his experiments that the dust most difficult to remove was combustible, and therefore composed *of organic matter*

The color of the sky the duration and colors of twilight are largely determined by the optical effects of dust motes in the upper air But dust owes its particular climatological importance to the fact that its particles serve as the condensation centers which seem to be necessary to initiate the formation of droplets of moisture which give rise to fog cloud rain, and snow

suffer. The greatest range of temperature is found where the land has the greatest power of absorption and radiation, as over deserts. The character of the soil has especial importance in its relation to the absorption and retention of water. Sand absorbs water most readily, but allows it to percolate rapidly. Therefore, a sandy surface quickly dries after a heavy rain, unless underlaid by an impervious layer. Clay absorbs water with difficulty, and gives it up slowly. Humus has extraordinary capacity for absorbing water, which it takes up slowly, but retains strongly. Damp soils are those which retain or prevent the percolation of water. Cultivation of the ground greatly enhances its capacity to store water. The atmospheric humidity varies with the moisture in the soil, and the temperature relations of the air approach in equal degree those found over water surfaces. The reflecting powers of the ground covering are of physiological moment, as witnessed in the glare from sandy deserts on the one hand, or mountain snow fields on the other.

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PHYSIOLOGICAL AND MEDICAL CLIMATOLOGY

The living organism responds to its physical environment While each climatic factor has a preponderant effect upon one or another physiological function, the fact that these functions are interdependent and that climatic conditions vary more or less a a whole makes the study of physiological climatology one of exceeding complexity The ideal scientific presentation of the subject would denote the relations between climate and the living organisms in the form of an equation On one side would be grouped the physical variables entering into the concept climate on the other side would stand the infinitely complex community of reacting cells of the body The science of medical climatology must attempt to present the integral effects upon the second term of the equation of mutations in the variables of the first This underlying mathematical conception of the subject is manifest in the actual examination by the laboratory worker of the physiologic effect of the change of individual climatic factors Moreover, the mathematical point of view has definite practical value in that it reveals the futility of expecting a solution of the problem without a full knowledge of all the variables which enter into it.

The Physiological Reaction to External Temperature—Temperature is biologically the most dominant factor of climate Metabolism of living matter goes on within a narrow range of body temperature Cold blooded animals whose chemical proces e in large measure rise and fall with external temperature have like plants, a geographical distribution strictly related to the thermal environment Warm blooded animals react to variations of external temperature in uch a way that, in general metabolism with production of heat is increa ed and loss of heat decreased by external cold, while the reverse reactions occur when the external temperature rises By these means a nearly constant body temperature is maintained under wide fluctuations of air temperature

The heat of the body is due to katabolism or the breaking down of complex into simpler chemical compounds in which process potential energy becomes liberated and kinetic The food is the fuel which supplies the body with all its energy and there is believed to be an exact equality between the energy estimated as heat lost to the food in the body and that set free in the vital proces es supposing the weight of the body to remain the same Therefore the body in its metabolism is subject to the law of the conservation of energy

Ob ervations on men confined in a calorimeter show exactly how much energy estimated as heat is lost to the body under different conditions in a given time It is obvious that to maintain the body unchanged it must receive in the food at least as much energy as it loses in its metabolism (for the full value of food etc see Chapter II of this volume)

The Influence of Vegetation on Climate—Forests have an important human interest in their efficiency as wind brakes Radiation and evaporation are increased over verdure-covered areas and, therefore, the general influence of vegetation is to cool the soil The average humidity of the air of forests is several degrees above that of the open The general effect of such growths is to conserve uniformity of temperature and moisture and to oppose extremes Only a few years ago it was generally assumed that vegetation, and especially forestation, had extreme importance both in increasing rainfall and in improving the capacity of the soil to absorb and retain water Deforestation has been charged with causing aridity of once fertile regions on the one hand, and with allowing the rapid run off of excessive precipitation in disastrous floods on the other An unprejudiced analysis of climatologic facts has led to the conviction that vegetation is only an effect and not a cause of rainfall Numerous factors are involved in the problem

Professor Willis L Moore finds that "In New England, where deforestation began early in history, the mean of the fluctuations in the rain curve is a steady rise since 1836 up to a few years ago, and in the Ohio Valley, where the forest area has been greatly diminished, there is no decrease of rainfall shown by the average of the fluctuations of the curve" He concludes "Precipitation controls forestation, but forestation has little or no effect upon precipitation The run-off of our rivers is not materially affected by any other factor than the precipitation Floods are not of greater frequency and longer duration than formerly" It appears that the capacity of soil to absorb and retain water is enhanced rather more by artificial cultivation than by mere vegetation The binding power of vegetation upon the soil is an important consideration

On the other hand, the existence and distribution of plant life are directly dependent upon temperature and humidity Good crops are raised by 'dry farming' in regions, such as Colorado, where the rainfall is insufficient to support spontaneous growth The main feature of the method consists in fine trituration of the surface soil It seems obvious that lumping of the earth in masses would not only facilitate the development of macroscopic interstices, favoring a run-off of water, but would *impede the penetration of the clods* On the other hand pulverization of the soil would both annihilate its drainage channels and set each particle free to exert its maximum adsorption on the falling moisture The distribution of plant life in general, other things being favorable, is determined by temperature ranges Plant growth does not take place until a temperature of about 43° F is reached The amount of growth depends upon the number of hours in a season in which the temperature is above this limit Of two places having the same mean temperature, one may be barren and the other contain a rich flora through favor of a short, hot summer

in climbing a certain height, which disappeared after the physical training of a summer *Training* is the process of physiological adjustment necessary in passing from one habit or environment to another Every organism has its individual range of physiological response to the process of training Somewhere on this scale whether it be constructed on the basis of external temperature or any other climatic factor is a point at which, for the moment is found the optimum of physiological response —or that response which best conserves the well being of the organism as a whole The numerical situation of this optimum varies with the individual and for the same person at different times Beyond the extremes of the scale life can no longer exist

The essential thesis of this argument is that climate, in its broad sense, is an indispensable factor in physiological therapeutics

The body temperature in man has been found by most observers to vary only within one degree during residence in opposite extremes of latitude The accuracy of most observations is impaired because the records have been obtained from the mouth or axilla This uniformity of body temperature under different external conditions is maintained by coordination between the nervous mechanisms for the dissipation and production of heat According to Vierordt, the relative loss of heat through various channels is represented in the following table

RELATIVE LOSS OF HEAT THROUGH VARIOUS CHANNELS

Channel	Per Cent	Calories
By urine and feces	1.8	4[illegible] 00
By expired air warming of air	[illegible]	84 [illegible]00
Vaporization of water from lungs	7.[illegible]	18[illegible] 1[illegible]0
By evaporation from skin	14.5	[illegible]4 1[illegible]0
By radiation and conduction from skin	73.0	1 791 8[illegible]0
Total daily loss		[illegible] 470 000

The relative values of these factors change greatly with external temperature and humidity Thus in warm weather the loss of heat resulting from the evaporation of perspiration rapidly augments The nervous mechanisms involved comprise the respiratory center the vasomotor center the sweat centers certain other secretory centers and the various afferent and efferent centers which connect them with the skin. The regulation of heat production involves chiefly the motor nerve centers with the motor nerves of skeletal muscles and the character and quality of the food ingested Calorimetric experiments on men and animals show that the respiratory exchange measured by the amount of oxygen absorbed and carbon dioxid exhaled increases with fall of external temperature In the case of man the increase of oxidation through cold is insignificant

Parallel with the increased ingestion of heat producing food, physiological combustions are increased in the cold, otherwise the level of body temperature could scarcely be maintained The four fifths or more of the energy of muscular contraction which appears as heat, not to speak of the warmth from circulation friction, are important sources of bodily heat All these facts harmonize with the ethnic experience that, broadly speaking, the peoples of the higher temperate latitudes are characterized by physical energy and mental initiative, while those of torrid zones exhibit a comparative bodily lassitude and mental inertia

In actual climates other factors than temperature, notably humidity of the air, enter into the physiological problem and demand a special discussion

External temperature has a fundamental causal influence on body metabolism It is a fair assumption that there is an optimum metabolism at which machine efficiency of the organism is at its acme, and that this condition represents the most perfect attainable standard of good health for the individual It seems probable, though it does not follow of necessity, that the ability of the tissues to adjust themselves to varying environment, and to produce the various biological antagonists against infectious disease, should manifest an intimate dependence upon this physiological efficiency In short, what we term "the resistance powers of the body probably vary in some direct proportion with that harmony of metabolism whose optimum is manifested by perfect mechanical efficiency Such a view finds luminous exposition in the clinical experience that an environment of open air provides the body with a more or less specific resistance against the advance of certain infections—notably tuberculosis It is commonly admitted also that tuberculous patients thrive better when they react to the cold of winter than when subjected to the heat of summer It is fundamentally important to realize that the community of living cells forming the body is a moving system, reacting instantly to every change of environment The resultant of such a physiological adjustment is subtended by a state of consciousness, a sense of comfort or discomfort, of well being or ill being This psychological condition is what determines man's estimate of climate, and I assume that it is the natural and, on the whole, most reliable test of the conservative or destructive tendencies of underlying physiological activities Our appreciation of a change is always measured by the state to which we have already become adjusted Thus, as Huggard points out, Ross and his party of Arctic explorers found the temperature of —29° to —25° F agreeable after they had been exposed to one of —47° F, and Peary's men complained of heat at 26° F after they had become accustomed to —13° F

Zuntz and his party in the Alps found that, in the springtime after a winter's inactivity, the guides suffered fatigue and metabolic disturbance

dents The tendency is to a reduction in physiological tone a lack at once in inhibitory force, and in active energy

Physiological Influence of Atmospheric Humidity—The watery vapor diffused through the air has extraordinary physiological importance not through specific action of its own but by modifying the effects of other climatic agencies, as heat cold wind, and light The vapor of water in the air, like a body of water upon the earth tends to the preservation of uniform temperature Watery vapor absorbs and renders latent a great deal of heat The warmer the air the greater its capacity for sustaining vapor, and thus accommodating a reserve of latent energy which must again become active when the vapor is condensed Through atmospheric humidity the earth is thus screened from the extreme intensity of solar insolation by day and the earth is protected from extreme chilling through radiation and evaporation at night The air in contact with a cooling surface is suddenly warmed when dew is precipitated As already mentioned the drying power of the air is measured by the percentage of watery vapor which it lacks toward saturation that is, it varies somewhat inversely with the relative humidity

It has been seen that the regulation of body temperature in man involves the regulation of the loss of heat by the skin In cold weather the skin is relatively dry and the radiation of heat is reduced by proper clothing and the body warmth is conserved on the principle of the domestic fireless cooker As the external temperature rises the skin circulation increases and the sweat glands give forth their watery secretion The evaporation of the sweat removes the excess of heat from the body When the air is still the relative humidity of the layer next to the skin is quickly raised so high as to impede further evaporation the air seems muggy, *and the subjective sensation is one of profound discomfort* A gentle breeze brushes away the moist coating and the refreshing cooling process continues A stronger wind especially when concentrated on a limited portion of the surface is apt to occasion such rapid chilling as to cause widespread circulatory disturbances which introduce a diversity of pathological conditions Herein is a field for investigation which includes numberless phenomena, from the stiff neck that follows a draft to the long list of respiratory infections that have some relation to surface chill The discomfort occasioned by localized cooling of the body gives rise in many people, to an instinctive aversion to drafts of air, which is worthy of special inquiry Howell quotes a case from Zuntz of a man who possessed no sweat glands In summer this individual was incapacitated for work since even a small degree of muscular activity would cause an increase in his body temperature to 40 C (104 F) or 41 C (105.8 F) This wonderful capacity of the body to regulate its temperature by evaporation was shown in the familiar experience of Blagden and Fordyce published in the eighteenth

if, by voluntary control, muscular movement and shivering are avoided Thus is manifest the purpose of the instinctive muscular activity induced by *falling temperature* *Rubner found the amount of CO eliminated* by a fasting guinea pig in air cooled to 0° C to be more than double what it was when at a temperature of 34 9° C (94 8° F), and this with a difference of but 1 2° C in body temperature

The general conclusion from numerous researches on this subject is that the intake of oxygen and output of carbon dioxid increase with lowering, and decrease with rising, temperature of the environment It is an interesting conclusion of Loewy that "the only involuntary regulator of temperature in a man exposed to moderate cold is the skin" But the range of this coordination has definite limitations Thus, both in man and animals, when the temperature of the calorimeter exceeds 30° to 35° C (86° to 95° F), the combustions of the body increase beyond their magnitude at 20° C (68° F) The writer has found that tuberculous guinea pigs seem to fail faster if kept at temperatures between 80° and 90° F

It seems very doubtful if such increased metabolism would be found in acclimated individuals living in the tropics Pfluger made the interesting observation that, in a curarized rabbit, in which the muscles cannot be innervated, the gas exchange rises and falls with the external temperature as it does in cold blooded animals The same effect was obtained in paralysis following section of the spinal cord in the neck It is a matter of medical interest to know that several observers agree that anesthetized mammals respond like cold blooded animals to alterations in *external temperature* (*The student of metabolism should consult the* masterly chapter of Graham Lusk on The Regulation of Temperature)

The investigation of the effects of climatic temperatures, especially in the tropics, on physiological functions offers considerable difficulties The conditions in hot countries are prone to be complicated by parasitic infections Thus, according to some observers, a decided degree of anemia *characterizes the inhabitants of hot countries the number of red* corpuscles in the blood falling to half that normal in temperate zones On the other hand, denizens of polar regions are said to show plethora and polycythemia

These conditions might be explained by abundant alimentation on the one hand, and parasitic infection on the other The influence of warm *countries seems to lower arterial blood tension The rate of* heart beat at the same time does not seem to be materially changed Evidence, of doubtful value obtained at surgical operations and *postmortem* examinations, indicates that residence in the tropics induces a hyperemia of the abdominal organs, on the other hand, the lungs contain less blood than usual

The general physiological effect of residence in hot countries seems to be epitomized in the muscular and nervous lassitude reported by resi

8 per cent of an atmosphere instead of a normal percentage of 11 to 17 (Loewy) It is therefore obvious that, as regards its content of O_2 and CO_2, the alveolar air is not only practically identical outdoors and in but that under ordinary conditions its variations make no impression on consciousness Many years ago Brown Sequard and D'Arsonval announced that the deleterious qualities of expired air depended upon poisonous organic matter contained in it They condensed the moisture in the breath of animals and injected the fluid obtained into other animals with fatal effects Other observers repeating these experiments failed to obtain the same results Finally the whole question was submitted to an elaborate critical experimental review in 1895 by Billings Mitchell and Bergey These authors concluded that the ill effects of respired air depended wholly on its temperature and humidity and not upon its increased content of carbon dioxid or any organic inclusion Experiments conducted by the writer were recently instituted to determine whether a condition of sensitization could be induced in animals by confining them in jars ventilated insufficiently for their needs Conclusions were deduced as follows

'Guinea pigs exposed to the rebreathed air, including cutaneous dust given off from other guinea pigs until its content in CO_2 is sufficient to cause excessive dyspnea manifest in the majority of cases, when re-exposed to the same conditions after the lapse of from twenty to eighty days in comparison with normal control animals an exacerbation in respiratory disturbance which suggests anaphylactic reaction

'Though carbon dioxid is the only agent in the exhaled air which is demonstrated as the efficient cause of dyspnea its presence is not necessary to the induction of the sensitive state there is even some evidence that its presence tends to avert sensitization'

The writer has found that guinea pigs sensitized by subcutaneous injection of horse serum are in a large proportion of cases temporarily de-sensitized by exposure in a horse stable This fact is crucial evidence that protein matter—whether from the skin or lung is doubtful—given off by the horse may when inhaled by a guinea pig produce in it immunologic reactions

From a noteworthy series of researches performed by Paul Heymann and Frecklantz under the direction of Flugge the conclusion seems justified that the subjective impressions that we have been accustomed to ascribe to disturbances of lung ventilation really depend upon modifications of skin ventilation The observations were made upon men confined in a closed chamber of three meters capacity provided with an electric fan When the air was kept in motion by the fan the subject under experiment remained free from unpleasant sensations in air which measured by ordinary standards was excessively foul When the fan was at rest and the air still the person confined in the chamber soon began to suffer

century These observers tested their own temperatures in rooms heated to various degrees They found that the effect depended on the humidity of the air 'Thus, after remaining fifteen minutes in a damp room heated to 54 4° C (129 9° F), the temperature of the mouth and urine was 37 8° C (100° F), but in a similar exposure in a dry room heated to 115 5° C (239 9° F) to 126 7° C (302° F), and in which beef steaks were being cooked by the heat of the air, did not raise the temperature of the body above the normal"

It is clear that the chief regulator of the body temperature, as external heat increases, is evaporation of perspiration, and that the rate of evaporation is closely dependent upon the relative humidity of the air The sensory nerves of the skin give fine warning of insufficiency in the physiological regulation through disagreeable sensations which we ascribe to mugginess or stuffiness of the air, and which are remedied, as will be seen later, by air renewal through "ventilation" When the external temperature falls much below that of the body, atmospheric humidity still has predominant interest, but in another direction When the air is cold and its humidity high, the skin loses heat to the moisture by *conduction* which accounts for the peculiarly chilling effect of damp, cold air Wind hastens this loss of heat, so that it is clear how the wind may make a hot day more tolerable and a cold one less so

Ventilation—Perhaps the greatest clinical discovery of all time is the empirical determination of the hygienic and therapeutic value of the open air We are not yet certain of the physicophysiological reactions which constitute the virtue of fresh air

Until recently it seemed clear that the subjective appreciation of air purity was a question of lung ventilation It was taken for granted that the 'bad air' of a closed and crowded room exerted its influence through a rise in CO_2 tension and fall in O_2 tension within the alveoli of the lungs Moreover, it was held that the expired air contained organic excretions which imparted to it poisonous qualities In short, the deleterious effects of respired air were attributed to its chemical qualities But Haldane and Priestley showed conclusively that, under a constant atmospheric pressure, the tension of CO_2 in the alveolar air remains practically constant The slightest increase in such tension automatically stimulates the respiratory center to more vigorous action "a rise of 0 2 per cent of an atmosphere in the alveolar CO_2 pressure being for instance, sufficient to double the amount of alveolar ventilation during rest" When a person under observation was made to rebreathe the air exhaled, he felt no abnormal subjective impressions until the CO_2 percentage in the air inhaled began to exceed 3 per cent These authors found also that diminution of oxygen in the inspired air produced no reflex effect on respiratory rhythm until its pressure fell to about 13 per cent of an atmosphere, which corresponds to an alveolar oxygen pressure of about

8 per cent of an atmosphere instead of a normal percentage of 11 to 17 (Loewy) It is therefore obvious that, as regards its content of O and CO the alveolar air is not only practically identical outdoors and in but that under ordinary conditions its variations make no impression on consciousness Many years ago Brown Sequard and D Arsonval announced that the deleterious qualities of expired air depended upon poisonous organic matter contained in it They condensed the moisture in the breath of animals and injected the fluid obtained into other animals with fatal effects Other observers repeating these experiments failed to obtain the same results Finally the whole question was submitted to an elaborate critical experimental review in 1895 by Billings Mitchell and Bergey These authors concluded that the ill effects of respired air depended wholly on its temperature and humidity and not upon its increased content of carbon dioxid or any organic inclusion Experiments conducted by the writer, were recently instituted to determine whether a condition of sensitization could be induced in animals by confining them in jars ventilated insufficiently for their needs Conclusions were deduced as follows

Guinea pigs exposed to the rebreathed air, including cutaneous dust given off from other guinea pigs, until its content in CO is sufficient to cause excessive dyspnea, manifest in the majority of cases, when reexposed to the same conditions after the lapse of from twenty to eighty days in comparison with normal control animals an exacerbation in respiratory disturbance which suggests anaphylactic reaction

Though carbon dioxid is the only agent in the exhaled air which is demonstrated as the efficient cause of dyspnea its presence is not necessary to the induction of the sensitive state there is even some evidence that its presence tends to avert sensitization'

The writer has found that guinea pigs sensitized by subcutaneous injection of horse serum are in a large proportion of cases temporarily de-sensitized by exposure in a horse stable This fact is crucial evidence that protein matter—whether from the skin or lung is doubtful—given off by the horse may, when inhaled by a guinea pig produce in it immunologic reactions

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Humidity influences the output of heat from the body in two very different ways It increases the conductivity of the atmosphere for heat—a cooling influence, and it interferes with the evaporation of perspiration—a heating influence What the net result will be depends upon which of these influences of humidity is predominant' It is pointed out that at air temperatures between 68 and 70° F neither high nor low humidities have marked physiological effects while the body is at rest. This, therefore is the optimum range of temperature for maintaining the comfort of inhabited rooms

Lee and Scott have recently reported experiments in which it was found that in cats confined for six hours in a ventilated box where temperature and humidity could be regulated at will the excised muscles at the end of this period showed a loss of work power when the air of the box had been maintained at high temperature and humidity (91 F and 90 per cent) as compared with normal conditions The sugar content of the blood diminished 6 per cent under the same circumstances

The present writer has pointed out as had M J Rosenau previously on the basis of experiments in anaphylaxis that substantial evidence exists for the absorption by the respiratory tract of protein matter diffused in the air with the result of producing profound changes in cellular irritability Therefore any practical view of ventilation which ignores chemical pollution of the air is unscientific and dangerous

Huggard quotes from Humboldt a striking description of the physiological conditions produced by hot, damp climates We had not yet been two months in the hot zone and already our organs were so sensitive to the slightest change of temperature that through shivering with cold we were unable to sleep and to our astonishment we saw that our thermometer registered 21 8 C (71 24° F) A change of not more than seven or eight degrees sufficed to bring about the opposite sensations of shivering and oppressive heat

The temperature humidity and motion of the air combine to determine physiological reactions of the utmost significance to the welfare of the body Though the discomfort aroused by a poorly ventilated apartment may not as demonstrated be due to chemical deterioration of the air nevertheless these sensations of ill being lose none of their value for hygienic prophylaxis The clinical experience which has demonstrated the debilitating effects of long continued confinement in close air as opposed to the invigoration attendant on life in the open finds explanation in the respective influence exercised by the two environments over the general resistance powers of the body The skin is a peripheral sensory organ specifically concerned in maintaining the hygiene of metabolism.

The Physiological Influence of Diminished Barometric Pressure—The mean pressure of the air at sea level may be assumed to balance a column of mercury 760 mm. about 30 inches high The total pressure is

from the headache, dizziness, fatigue, nausea, etc, characteristic of extremely poor ventilation In this condition the patient was allowed to breathe, through a tube fastened in the wall of the chamber, pure air from outside No relief was experienced through this procedure, nevertheless, when the fan was started and the air put in active motion, the person under experiment again became comfortable

Experiments by Leonard Hill and his colleagues have confirmed Flugge's contention, that the subjective impressions aroused by lack of ventilation in closed spaces are nowise dependent upon the chemical constitution of the air breathed but rather on its temperature and its humidity, which interfere with the heat regulation of the body by restricting transpiration from the skin The profound psychophysiological influence of temperature sensations derived from the skin is further evidenced by the curious fact observed by Boycott and Haldane, that when the air, whatever its real temperature, gave the impression of warmth of an unpleasant kind, the tension of CO_2 in the lung alveoli became lowered They write "We think, indeed, that it is one of the physical expressions of the feeling of warmth and slackness while the rise in the CO_2 tension (in the alveoli) is associated with the general exhilaration and stimulation produced by cold air"

Rosenau and Amoss write "Benedict has kept persons in his calorimeter breathing and rebreathing the same air with a CO_2 content as high as 2 per cent for twenty four hours without discomfort, the only precaution being to keep the temperature down and to remove the moisture"

Hough describes an experiment in which a subject was confined for an hour or more in an air tight box "The percentage of CO_2 rose to 50 or more parts per 10,000 When the observer opened the door the odor of the air within was almost overpowering, and yet, provided the water vapor was absorbed and the temperature of the box kept down, the subject of the experiment had not only been unconscious of this odor, but had actually suffered no discomfort" In his excellent essay the author clearly indicates the physiological relations of atmospheric humidity with rising temperature When the air temperature rises above 70° F, the body temperature would become elevated, but for the evaporation of perspiration "When, however, owing to high humidity, evaporation is lessened, blood rushed in large quantities to the skin *at the expense of the flow to other organs* the temperature of the skin is raised, and so heat transfer by radiation, conduction, and convection is facilitated The normal temperature of the body is approximately maintained, but it is at the expense of the working efficiency of other organs, and especially that of the brain In these facts we probably find the true explanation of the dull, heavy feeling the difficulty of attention, and the discomfort both of the muggy summer day and of the crowded, ill ventilated room

wide limits without producing obvious reaction Nevertheless when the partial pressure of oxygen falls to a certain level about 13 per cent of an atmosphere the tension of the gas in the lung alveoli is so lowered that the body cells suffer from the lack of oxygen

Physiologists have generally maintained that the respiratory exchange between the alveolar air and the blood was regulated wholly by the physical law for diffusion of gases According to this law, a gas must pass from a medium where its tension is higher to one where it is lower until there is equilibrium of tension But Haldane and Smith maintain that the tension of oxygen in the blood leaving the lungs is much higher than that in the alveolar air and therefore diffusion alone does not explain the passage of oxygen from the air of the pulmonary alveoli to the blood Haldane Douglas Henderson and Schneider submitted the physiological influences of high altitudes to a searching investigation during a sojourn of thirty five days on the top of Pike s Peak Colorado (elevation 14 000 feet) They conclude that all the vital modifications witnessed at high altitudes are the result of one cause, lowering of the oxygen pressure in the air

They found, ' after acclimatization the resting arterial oxygen pressure had risen about 35 mm of mercury above the alveolar oxygen pressure, whereas at or near sea level the resting arterial oxygen pressure is no higher than the alveolar oxygen pressure The raising of arterial oxygen pressure is attributable to secretory activity of the cells lining the lung alveoli, and is a most important factor in the acclimatization On breathing air rich in oxygen the secretory activity was rapidly diminished The fundamental significance of this alleged oxygen secretion coordinate with the respiratory needs of the body may well hold the attention It has been shown by Zuntz and others that the suboxidation of the tissues resulting from a critical lowering of alveolar oxygen tension is accompanied by the accumulation of acid substances especially of lactic acid in the blood These acid substances in the blood stimulate the respiratory center and lower its threshold of irritability for CO so that the center is excited to work under the stimulus of a lower tension of CO in the blood than would normally be effective

It seems probable that this metabolic disturbance which is particularly prone to affect newcomers in high altitudes is directly responsible for many of the phenomena of *mountain sickness* Mountain sickness is a curious symptom-complex manifested in various degrees by people who mount comparatively suddenly to high altitudes In Europe the disorder is said to commonly manifest itself at elevations as low as 9 800 feet In America the critical level seems to be considerably higher The subjective symptoms are those of dyspnea especially with exertion and a feeling of oppression in the chest

Disgust for food and nausea leading to vomiting gave name to the

the sum of the partial pressures of all the components of the atmosphere. With elevation above sea level the fall in the barometer is measured by the mass of air left below. The rate of fall is approximately 1 mm. Hg for every 40 feet of ascent in free air, or 1 inch per 1,000 feet. With ascent the relative proportion of the constituent gases is maintained, except that the watery vapor is chiefly confined to the lower levels. Mere difference in atmospheric pressures appears, within wide limits, to be indifferent to living beings. The tension of the gases dissolved in the body fluids soon balances that of the surrounding air, so that the physiological phenomena of a rarefied atmosphere cannot be properly ascribed, as is so often is done, to a suction pump effect upon the pulmonary apparatus, although it is true, a given amount of gas confined in the intestines expands in proportion to diminution of external pressure.

The importance of the time element in the adjustment of internal to external gas pressure is well illustrated in the phenomena of "caisson disease." In subaquatic constructions workmen in caissons are sometimes subjected to air pressures of three or four atmospheres. On returning to normal conditions, if the decompression is too rapid, peculiar symptoms, tingling, cramps, etc., are experienced, and paralysis or even death may ensue. *Postmortem* examination shows that air emboli are set free in the central nervous system, leading to "necrosis in the region of the posterior and lateral columns of the cord, especially in the cervical region." Such pathological results are avoided by slow decompression covering a period of one to two hours. The physiological effects of high altitudes are probably all to be explained by the lowered pressure of oxygen, and possibly of carbon dioxid also, in the alveoli of the lungs. In the dry atmosphere, at 760 mm. pressure, the partial pressure of oxygen is about 159 mm. That of carbon dioxid is negligible.

Zuntz and Loewy[1] analyzed the air expired by human beings and calculated that the composition of alveolar air varied between the following limits: oxygen between 11 and 17 per cent of an atmosphere, carbon dioxid between 3.7 and 5.5 per cent of an atmosphere. Or, in terms of tension, the partial pressure of oxygen ranged between 83.6 mm. Hg and 129.2 mm., while that of carbon dioxid varied from 28.1 mm. Hg to 41.8 mm. Attention has already been called to the demonstration by Haldane and his associates that under ordinary conditions, the partial pressure of CO_2 in the pulmonary alveoli of a given person is remarkably constant. A very slight increase in the CO_2 tension leads to hyperpnea and exaggerated elimination of CO_2 from the body, while, on the contrary, a lowering of CO_2 tension induces physiological apnea, or respiratory rest, and consequent accumulation of CO_2 in the body. That is, CO_2 is the normal stimulus of the respiratory center. On the other hand, fluctuation of oxygen tension in the alveolar air may occur within

[1] Howell, W. H., Textbook of Physiology, 1907.

wide limits without producing obvious reaction. Nevertheless, when the partial pressure of oxygen falls to a certain level, about 13 per cent of an atmosphere, the tension of the gas in the lung alveoli is so lowered that the body cells suffer from the lack of oxygen.

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disorder The sufferer is absorbed in his own misery, and the mental disturbance may proceed to temporary alienation The skin and lips are blue, the circulation and respiration distressed, and the slightest exertion exaggerates intolerably all symptoms The inhalation of oxygen gas relieves at once, for the time, the morbid condition After a quiet sojourn of two or three days at the altitude provoking the sickness, the body usually becomes accommodated to the new conditions, and a fair amount of exertion may be taken without undue distress Cyanosis of the skin disappears, the lips again become red, and pulse and respiration return to about normal A review of the literature on mountain sickness would reveal a curious multiplicity of explanations for the disorder The dogmatic statement may be ventured that the final cause of the symptom complex lies in an inadequate oxygen supply Haldane and his colleagues on Pike's Peak found that, when samples of the venous blood were shaken up with air drawn from the alveoli of the lungs, the blood remained dark, although, at the same time, the arterial blood must have been bright red, as shown by the color of the lips and mucous membranes of the subjects This experiment indicates both that the oxygen tension in the alveolar air was at least no greater than that in the blood from the right heart, and also that active absorption of oxygen by the alveolar epithelium must occur under such conditions

Clinical experiences have led the writer to suspect that an *important* factor, if not the internal exciting cause, in mountain sickness lies in circulatory disorder resulting in accumulation of blood in the venous system through inefficient cardiac action, proceeding to dilatation of the right heart, and, in extreme cases, to insufficiency of the tricuspid valves It is easy to believe that anoxemia would early depress the cardiac function This would lead to plethora of the lungs and general venous system, and provoke the symptoms characterizing the disorder Unfortunately no opportunity has yet occurred to try out this theory experimentally, as by a study of the jugular and liver pulsations

Physiological study of persons and animals removed from low to high altitudes shows a profound alteration in metabolism, especially of the hemopoietic system The absolute and relative amounts of hemoglobin and of the red blood-corpuscles are greatly increased at high altitudes Zuntz and his colleagues working on Monte Rosa, altitude 14,960 feet, showed that the activity of the red bone marrow, as shown by its hyperemia and increased number of nucleated red cells, was accelerated by low barometric pressure The number of red blood corpuscles has been found to rise from 5 000 000 at sea level to 8 000,000 at about 14,000 feet The hemoglobin increases by 20 to 30 per cent or more under the same conditions

Haldane and his coworkers made a critical study of the blood as affected by barometric pressure They found that "the percentage of hemoglobin increased for several weeks on the summit of Pike's Peak

and varied in various acclimatized persons from 115 to 154 per cent The number of red corpuscles increased parallel with the hemoglobin' At high altitudes symptoms of anemia may attend a hemoglobin per cent that is normal for sea level

Much of the work that has been done in this field is held by Burker and his associates to suffer from defects in method These observers maintain that the increase in the red blood count for moderate elevations, up to say, 10 000 feet, is much less than has usually been asserted

Abderhalden and others have considered the altitude polycythemia to be the result, not of increased blood formation but of blood concentration from excessive evaporation Another view assumes that under low barometric pressures there is an unusual accumulation of corpuscles in the peripheral vessels from which estimations are made The excellent work of Loevenhart and his colleagues seem to have disposed of these doubts as to the existence of a true altitude polycythemia and the active stimulation of the blood forming organs through reduction in the partial pressure of oxygen

Loevenhart confined rabbits in ventilated boxes in which, while the total barometric pressure was kept constant the proportion of oxygen was widely varied It was found that under these conditions, lowering the oxygen tension produced blood changes similar to those realized when a like fall in oxygen pressure was due to elevation above sea level

Reflecting on the reason for these changes in the blood at first view there might seem a paradox of nature in the provision of an excess of oxygen-carrying material in proportion to the diminution of oxygen to be carried On the other hand the conception is incontrovertible that the hemoglobin of the body is not only a carrier but a storehouse for oxygen and the excess or *luxus* of this stored oxygen must be greater the lower the oxygen pressure in the alveolar air in order to meet the demands of muscular activity The relation of this respiratory factor of safety to the nutritional demands determining a physiological dietary touched upon in a preceding section is not without suggestiveness Barcroft and King have experimentally demonstrated the probability of hemoglobin serving in certain lower animal as a storehouse for oxygen, which is given up to the tissues as emergencies arise The dissociation of oxygen from its carrier is greatly accelerated with rise of temperature and it is highly probable that the elevation of temperature occurring in active muscles is a definite device of nature to make loose the oxygen when needed

As regards the colorless corpuscles of the blood G B Webb and his associates at Colorado Springs altitude 6 100 feet find that there is a relative and absolute increase in the number of lymphocytes, including especially the large mononuclears in the blood of persons removing from lower to higher altitudes They find that the proportion of lympho-

cytes rises from an average of 37 per cent at sea level to 44 per cent at Colorado Springs, and to 54 per cent at Pike's Peak.

O. M. Gilbert of Boulder, Colorado, has repeated these observations at various altitudes varying from 9,000 feet above to 120 feet *below* sea level (in the Salton Sink of California). He found the highest ratio of lymphocytes (43.5 per cent) in the blood of persons residing below sea level. At Boulder, elevation 5,380 feet, the proportion of lymphocytes was 42.6 per cent, at Phoenix, Arizona, 1,100 feet, 41.5 per cent, at Gold Hill and Ward, Colorado, 8,500 to 9,200 feet, 40.5 per cent, at Aurora, Illinois, 500 feet, 38.6 per cent. In short, the results indicate that the lymphocytosis is not a function of altitude per se, but of some other factor.

Janet H. Clark refers to the lymphocytosis excited under certain ultraviolet rays, and possibly the excess of these rays in the sunlight of special regions completely explains the metabolic change.

Insolation.—In high altitudes the intensity of insolation is great because the air holds but little moisture to absorb the rays; for the same reason, the heat radiated from the earth is not returned near the surface but penetrates to upper levels. There is great difference, accordingly, between the temperatures of day and night, and between sun and shade. In winter an invalid may sit comfortably in a solar temperature of 90° to 100° F., while a thermometer hung in the shade within arm's reach registers below the freezing point. As it is the shorter wave-lengths of solar energy which are subject to atmospheric absorption, the light of elevated regions is peculiarly rich in these "chemical" rays. The intense illumination is probably largely responsible for the restlessness and irritability witnessed in unacclimated persons at high altitudes.

The physiological and psychic influence of light makes it a climatic factor. Major C. E. Woodruff charges the intense solar illumination with the evils, especially of the nervous system, which make difficult the residence of white people in the tropics.

According to him, light is the important agent in the production of neurasthenia and multifarious allied nervous disorders, and persons of blond complexion are especially subject to its evil influences. It seems highly probable that the debilitation induced in the tropics is due rather to the combined influences of heat and humidity than to excessive illumination. Light is indispensable to normal life, and, if its excess leads to physiologic disturbance, it becomes all the more imperative for the climatic therapeutist to consider this agent specifically in his recommendations.

The radiant energy of the sun is undoubtedly a powerful physiological stimulus, capable of working either good or harm to the body. Heliotherapy is in an empirical stage. Such experiences as those of Rollier in the cure of surgical tuberculosis under sunlight deserve critical confirmation. Webb correctly urges caution in the application of the method

The writer saw one of his patients who had apparently cured himself of a severe ulcerative tuberculous laryngitis by the daily application, for a few minutes, of sunlight to his larynx. The light was reflected by a pair of polished metal mirrors and guided by a laryngoscope. It was presumed that the ultraviolet rays, probably excessive in the Colorado sunlight, were the efficient agent.

The study of the vital reactions to light, and especially to ultraviolet rays, has become an important and rapidly developing branch of physiological physics. Edgar Mayer has brought together much information on this subject from the therapeutic viewpoint.

Under certain conditions visible light assumes as drastic a physiological rôle as the ultraviolet rays. As noted by Mrs. Clark, it is possible to sensitize living cells just as one sensitizes a photographic plate, and produce an abnormal condition in which visible light is as active as ultraviolet. This phenomenon has been called photodynamic sensitization. Although a great many substances sensitize in vitro, only eosin, chlorophyll and certain derivatives of hemoglobin have so far been found effective in vivo, and the only markedly effective sensitizer for higher animals is hematoporphyrin. This substance is derived from hematin by removing the iron. It is said that traces of hematoporphyrin occur normally in the urine, but the quantity becomes significant after the abuse of certain drugs, as sulphonal and trional, and in some people it is excreted without obvious cause. Such persons are said to be exceedingly sensitive to light upon the skin. An animal may be wholly unaffected by the injection of hematoporphyrin in the dark while it soon succumbs to a much smaller dose if maintained in the light. Hausmann injected white mice with it and found 0.01 gram harmless in the dark, while 0.002 gram will bring on acute symptoms in the light. There is a marked but temporary hyperemia of the ears, nose and tail, and after a period of great activity the animal becomes quiet, shows dyspnea and dies in one to three hours.

Such facts as these suggest a line of investigation which may give to light an importance in medical climatology hitherto undreamed of.

It has already been stated that *temperature* takes the first rank in determining the physiological relations of climate. But it has long been clear that the *feeling* of heat, or sensible temperature, may vary widely from the air temperature as measured by the ordinary thermometer. Professor M. W. Harrington, former Chief of the U. S. Weather Bureau, was apparently the first to definitely point out that the sensations of temperature run much more nearly parallel to the readings of the wet bulb than of the dry bulb thermometer.

Accordingly, in dry air, in which the heat of the body is carried away by evaporation or perspiration, the weather may be comfortable when at the same air temperature in a humid locality the heat would be oppre

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According to him, light is the important agent in the production of neurasthenia and multifarious allied nervous disorders, and persons of blond complexion are especially subject to its evil influences It seems highly probable *that the debilitation induced in the tropics is due rather to* the combined influences of heat and humidity, than to excessive illumination Light is indispensable to normal life and, if its excess leads to physiologic disturbance, it becomes all the more imperative for the climatic therapeutist to consider this agent specifically in his recommendations

The radiant energy of the sun is undoubtedly a powerful physiological stimulus, capable of working either good or harm to the body Heliotherapy is in an empirical stage Such experiences as those of Rollier in the cure of surgical tuberculosis under sunlight, deserve critical confirmation Webb correctly urges caution in the application of the method

to a condition known as *pneumonokoniosis* Fibroid changes are induced by irritation from the foreign particles and considerable areas of the lung tissue may be replaced by solid nodules, or masses of deeply stained fibrous tissue Chronic bronchitis and emphysema are the characteristic clinical sequences The familiar 'miners consumption' is anatomically a pulmonary fibrosis In the lungs of a stone-cutter, forced to abandon his occupation on account of increasing dyspnea, the X ray plate showed me dense shadows radiating from masses at the roots of the lungs and involving the greater portion of the organs There was no evidence of tuberculosis in this case Lungs so affected seem to lose much of their normal immunity against bacterial infection In the mining regions of Colorado it is not uncommon to find superb athletes suddenly succumbing to an intractable form of pulmonary tuberculosis It is not improbable that the high mortality from pneumonia witnessed in similar districts is likewise associated with dust inhalation The intimate effect of inorganic inclusions on the vital resistance of the lungs is emphasized by J M Anders, who quotes Scurfield's observations on occupation mortality in Sheffield 'the death rate of grinders from phthisis is more than six times, and the death rate from other respiratory diseases nearly three times that of the average male while the death rate of cutlers from phthisis is nearly three times and from other respiratory diseases nearly four times that of the average male' The quality of the foreign matter inhaled seems not to be indifferent thus according to Osler coal miners are not especially subject to phthisis In his experiments on dust Tyndall found the air exhaled toward the end of expiration to be free from solid particles, a fact significant of the amount of dust that must be retained In manufacturing centers the smoke from burning coal composed chiefly of carbonaceous particles with a considerable content of CO and SO probably has important relations to the public health The sulphurous acid is especially irritating to the respiratory mucous membrane Under the action of oxygen and moisture it becomes converted into sulphuric acid F W Schaefer calculates that there are daily discharged from chimneys into the air of London about 300 tons of soot, 90 000 tons of carbon dioxid and 2 700 tons of sulphur dioxid

These bodies are all much heavier than air and tend to settle The solid particles at least form foci for the condensation of moisture, so that fogs impregnated with the gases of combustion are readily generated Statistics show that morbidity and mortality from respiratory diseases are greatly increased during heavy fogs in manufacturing districts It has been calculated that steel dust from the brake-shoes of moving trains formerly permeated the air of the New York subway to the extent of one ton in a mile of the tunnel

The figures reported probably should be modified as the result of the application of smoke consuming devices.

sive Wind movement greatly enhances evaporation and the cooling effect of dry air Isotherms plotted from readings of wet and dry bulb thermometers, respectively, differ widely in their course, and we find a physical explanation of the coolness felt on entering the shade on a summer's day in arid regions In the winter, by reason of the low humidity, little heat is lost to the body by conduction Therefore, resorts in elevated regions tend to seem much cooler in summer and warmer in winter than places on the same parallel near sea level

Professor Cleveland Abbe points out that different individuals respond variously to the same physical environment, as does one and the same person at different times, as before and after eating Observing his own sensations, with the wind blowing five miles an hour, he noted the following results

INDIVIDUAL REACTION TO PHYSICAL ENVIRONMENT

Temperature —Degr. F	Relative Humidity	Subjective State
80	20	Feels fine
40	60	Feels fine
20	80	Weather very raw
60	80	Comfortable
80	100	Suffocating

In his recent study of the influence of climatic factors on human efficiency in its broadest sense, Professor Huntington gives the preeminent place to temperature He writes The law of optimum temperature apparently controls the phenomena of life from the lowest activities of protoplasm to the highest activities of the human intellect"

In an essay like this it is impossible to give a detailed discussion of the modification of physiological functions induced at high altitudes The monumental works of Paul Bert of Mosso, and of Zuntz and his collaborators, together with the researches which have been cited here, represent the essentials of our present knowledge of the subject

The science and art of aviation as developed in the late War do not appear to have, as yet, added much to our knowledge of high altitude climatology It was found necessary to subject candidates for aviation to elaborate tests as to the celerity and range of their physiological accommodation to the conditions of high flying

Dust and Atmospheric Impurities—Impurities in the atmosphere in the form of dust and noxious gases, not to speak of bacterial and other contaminations, have undoubtedly great though little investigated, effect on human health The lungs are the organs specifically affected The solid particles inhaled to a greater or less extent, penetrate the bronchial mucous membrane and are distributed thence by the lymphatics, leading

But the mental state is still refractory to mathematical exposition, and practical clinicians are turning back to that viewpoint of life from which the mind is regarded as an ever acting and often predominant energy in physiological processes.

Madden writes: "The Stagyrite who knew all things and treated of them and some others, makes excellent observations on the indispensable necessity of serenity of mind, hopefulness and even cheerfulness for health of soul or body." When the change of climatic stimuli relieves ennui, awakens an interest in nature, or excites zest for mental effort, it tends to produce that cheerful serenity of which Aristotle recognized the value. The principles of climatic treatment are founded on psychology as well as physiology.

Application of Climate to Treatment of Disease

It would seem at first sight easy to determine from empirical observation the climatic conditions remedial for various pathological states. But experience shows that benefits which had apparently been originally derived from the climate of some definite locality finally ceased to reward the seekers of health, so that factors other than those of climate were brought into consideration. Resorts for the tuberculous, for example, that once seemed salutary have time and again developed into hotbeds of the disease. No fair estimate of the physiological influence of the tropics can be made until infections incidental to the hot zone are under sanitary control. In short, the causes of disease must be understood before a scientific application of climatic therapeutics can be hoped for.

Again, unnecessary obscurity has been thrown around the subject of physiological climatology by the frequent failure to recognize that, in every place, many of the physical factors of climate are subject to immediate artificial change to a degree which it would require long journeys to realize by geographical means. Temperature, humidity, air movement, insolation, are largely subject to artificial regulation.

The one disease involving consideration of climatology is tuberculosis.

Tuberculosis.—When the pathogenic organism of tuberculosis was discovered, the last doubt was removed as to the reason why resorts which originally seemed favorable to recovery from the disease so often proved later to be danger spots for its acquisition.

Pace the claims for the remedial powers of tuberculin, the years have yielded but one indispensable agent in the prevention and cure of tuberculosis—the open air. It is curious how little the crudity of this clinical finding has been refined. We have been at a loss for definite explanation of the hygienic virtues of open as compared with closed air. Referring to a preceding discussion on the physiology of ventilation, the contention of Flugge seems sustained, that the morbid sensation through which we

White and Shuey found it extremely difficult to estimate the morbific influence of smoke in the air of manufacturing centers They conclude, however, that there is a general tendency of the tuberculosis death rate to rise as the number of smoky days in the city decreases, there is a general tendency for the number of deaths from pneumonia to fall as the number of smoky days in the city decreases"

It is obvious in estimating the hygienic relations of atmospheric impurities that these should be primarily divided into two groups according to their solubility or insolubility in the body fluids To the first class, including sulphuric acid, etc, we might perhaps expect relatively acute physiological response The second class operates slowly through structural alterations of the lungs manifested as more or less extensive pneumonokoniosis

A J Lanza of the National Health Council, has analyzed the data presented by miners consumption" as it occurs among the workers in the Joplin mines of Missouri The mines produce lead and zinc and the offending dust is siliceous from powdered flint Miners' consumption is due to the deposit in the lungs of solid particles, the irritation of which sets up a progressive fibrosis The early symptoms of the disorder are a gradually increasing dyspnea on exertion, diminished respiratory expansion and pains in the chest Many of the victims examined had been at work for ten to fifteen years, but it was not uncommon to detect signs of silicosis in those who had worked less than a year in the mines Sooner or later the subject of miners' consumption is prone to develop either tuberculosis or pyogenic infection of the lungs or both Out of 720 miners examined by Lanza 433 had miners' consumption and of these 103 showed tubercle bacilli in the sputa The numerous X ray pictures of the chest which illustrate this research are strikingly suggestive of the plates obtained in pulmonary tuberculosis of glandular and bronchial type with bilateral distribution of disease In advanced cases the great masses of shadow, which are visible on the X ray plates, can be distinguished from those of ordinary tuberculosis only through the lack of signs of cavitation

The hygienic importance of this subject must be greatly enhanced when, to the inorganic dust, are added putrescible substances and pathogenic microorganisms Moreover, if the conception of atmospheric pollution is broadened to include not only inert suspensions, but the living insects which transport infectious matter, control of the purity of the air must banish much of the disease which now afflicts mankind Wind and rain are the natural purifiers of the air, as regards accidental contaminations

The Psychology of Climate—The demonstration within the past half century that the law of the conservation of energy applies to the metabolisms of the living body led to a mechanical view of vital processes which only incompletely represents the forces that control the human being

But the mental state is still refractory to mathematical exposition and practical clinicians are turning back to that viewpoint of life from which the mind is regarded as an ever acting and often predominant energy in physiological processes

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recognize the impurity of respired air are not due directly to acquired chemical properties of the air, but to the irritation of certain sensory nerves of the skin brought about by a rise of temperature combined with a high degree of relative humidity The nerves specifically concerned in these sensations would seem to be those delegated to temperature sensations; moreover, in the clothed subject, the skin of exposed parts, the head, neck, hands, wrists, possibly the lining of the nasal canal, would seem to be of relatively paramount importance In explaining the maintenance of a constant body temperature under wide thermal variations of the air, we find no difficulty in ascribing profound alterations in metabolism to stimuli arising in the temperature nerves of the skin From the same point of view the suggestion is obvious that the sensations of comfort or discomfort aroused in "good" or "bad" air are but incomplete conscious expressions of tissue reactions which determine the molecular efficiency of the machine, and incidentally regulate the production of substances protective against disease While heat and humidity are of predominant importance in the excitement of cutaneous sensations leading to feelings of well being or ill being it would be a too narrow view which would restrict to the action of these physical agents the multifarious sensory impulses, largely operating through the consciousness of pleasure and pain, through which the metabolisms of the body are, I believe, largely ordered

Thus nature, through visual and auditory impressions, tends to generate an æsthetic state, which is a potent addition to that mental atmosphere which favors recovery from tuberculosis

It is worth while, in passing, to point out that the response of the body to the manipulations of hydrotherapy is, in large measure, but a demonstration of the physiologic influence of temperature and moisture on cutaneous sensations

These reflections point to a physical basis for the known physiological effects of life in the open, and make it conceivable that all the advantages of such an environment might be secured indoors under artificial regulation of temperature, humidity, air movement, illumination, and other factors, physiologic and psychic, of the outside climate

In short, the facts point to the conclusion that the "resistance powers" of the body, aside from those specific immunities developed in response to substances in the circulation, are developed as reactions to afferent nerve impulses, or sensory impressions, which spring for the most part from the cutaneous surface [3]

The victim of pulmonary tuberculosis, thrilled with sickening chills along his spine, is prone to huddle over a stove in a closed chamber, or

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There is an analogy between the action of these trophic afferent impulses and that of the biochemic antigens which stimulate the tissues to produce immune bodies. Cf the suggestive paper by Crile

to seek relief in a land of perpetual summer But practical clinicians have found that recovery from the infection is apt to be furthered rather in a somewhat variable and rigorous than in an equable climate, and it is the general testimony from health resorts that patients commonly do better in winter than in summer It is significant that the same patient who left to his own devices had dreaded a fall of air temperature below 72° F under proper therapeutic control learns to rejoice in the crisp freezing air of a northern winter His point of view has been so altered by training that his feelings of pleasure and pain resume their normal function as sentinels to conserve his well being He breaks the vicious circle in which a morbid sensation led to a hurtful act (for the specific indications for the application of the open air treatment in pulmonary tuberculosis see Volume II Chapter XXV)

When the conception obtained currency that the open air was the most salutary environment for the consumptive, a tendency was manifested by certain phthisiographers to estimate as of equal therapeutic value all open air and to decry the hitherto assumed virtues of climatic change While admitting that the climate of the back yard was more remedial for the tuberculous than the climate of the adjoining kitchen they would not grant that a still greater deviation in meteorologic conditions to be found in distant resorts could have healing virtues in excess of those to be found on a city lot This question can only be decided empirically, but the reason cannot but be impressed with the physiological facts of climate, such, for example as the specific stimulation of the blood forming organs, of tissue proteid assimilation etc. which occur in moderately high altitudes The unbiased mind must grant at least, that every climatic complex operates for or against the recovery of a consumptive in proportion as it excites conservative or destructive physiological reactions The impression has gained ground that a cure of tuberculosis at high altitudes leaves the patient especially liable to relapse or to again contract the disease on returning to lower levels It is probable that the only truth behind this belief is the fact that many cases of arrested pulmonary disease can pursue a useful life only under certain favorable conditions The tendency of persons returning home after achieving arrest of their disease, is to abandon the hygienic methods to which they owed improvement It is also true that the temperament and constitution of one who has harbored tuberculosis ofttimes demand the stimulating conditions of high altitude to maintain a feeling of well being which of itself must be a powerful aid to the resistance powers The body is probably vastly more sensitive to the influence of environment and is subject to a wider variety of physical stimuli than we have any idea of An experimental analogy for this position is offered by the exceedingly suggestive results obtained by Reid Hunt in his investigation of the effects of a restricted diet and of various diets upon the resistance of animals

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Rheumatoid Diseases—Painful affections of the connective tissues grouped under the term "rheumatoid diseases" are common in high altitudes their incidence probably bears an inverse proportion to the metabolic reactive power of the individual On the contrary *acute articular rheumatism* is less frequent than at sea level

The writer has had intimate opportunity of studying the case of a man who in Denver suffers much from ill-defined pains, at times characterized as muscular rheumatism and headaches which are relieved by salicylate of soda These symptoms disappear on a journey to sea level and remain in abeyance for some weeks after his return

Respiratory Affections—*Catarrhal conditions and bronchitis* as a rule are most favorably influenced in a climate of moderate humidity Newcomers in Rocky Mountain resorts habitually complain of irritative symptoms which are due to drying of the mucous membranes

Tuberculous laryngitis and other organic respiratory affections, though primarily contra indicating dry air not uncommonly in elevated regions find amelioration in the establishment of a general improvement in well being Theory and experience agree in the teaching that the mortality from *lobar pneumonia* increases in high altitudes Nevertheless practitioners in moderately elevated regions will agree with J N Hall, who from a wide experience concludes "I believe from this study that the mortality of acute pneumonia is not materially affected by altitude until one passes beyond an elevation of 6 000 or 7,000 feet"

Certainly the pneumonia morbidity and mortality in Denver are not in excess of those for the same disease at sea level

One of the most curious of clinical experiences with *bronchial asthma* is the frequent complete relief afforded at elevations of a mile or so above sea level On the contrary the subjects of *emphysema* are not apt to do well

Heart Diseases—Heart diseases are benefited or made worse in high altitudes, in proportion to the power of the heart to respond to excessive demands upon it and thus increase its range of accommodation.

The prescription of mountain climbing for chronic heart disease has a sound physiological basis Nevertheless when a physician at an elevated resort finds it difficult to restore a broken compensation he desires above all things to see his patient transported to a lower level

While the body is at rest the mechanical conditions of the circulation are practically identical through a wide range of elevation above the sea but the demands of muscular exertion call for an increase of cardiac activity which is excessive in proportion to the altitude Acclimatization, or training greatly expands the limits through which the heart can adjust itself without overstrain

R H Babcock is probably correct in his assumption that the condition of mitral stenosis is one which, for mechanical reasons, especially

to certain poisons' He found that the resistance of some animals to certain poisons may be increased fortyfold by changes in diet, the converse effect may follow an appropriate dietary The resistance of animals to the poison was directly related to certain internal secretions, particularly that of the thyroid gland, whose production is modified by diet Season has an important effect upon the resistance of animals to certain poisons, in some cases these effects seem to depend upon seasonable variations in the activity of the thyroid"

The writer has recently been impressed with the importance of considering the acid alkali balance of the blood as a factor affecting tissue resistance Where a condition of acidosis exists, as may be manifested by an excess of acetone in the urine, mysterious disorders may sometimes easily be corrected by the application of appropriate alkaline and dietetic treatment There is reason to believe that the backsets to which many tuberculous invalids are prone without apparent cause often find their explanation in a recurring acidosis

In an essay like this only general relations of climate to special diseases can be touched upon The works of Huggard, Solly, and others must be consulted for details

Anemia —Efficient operation of the blood forming organs is a fundamental requirement for health Aside from the specific effect of infections, the state of the blood has a direct relation to climatic environment Residence in the tropics is said to induce anemia, whereas removal to an invigorating climate restores the blood The work of Zuntz, Haldane, and others, on high altitude physiology, seems to demonstrate that the diminution of oxygen tension in the air specifically stimulates the bone marrow, and probably other sites of blood formation, to excessive activity

Therefore, even at moderate elevations of 3,000 to 5,000 feet the red blood count and the hemoglobin percentage exceed those of people at sea level At high altitudes health demands a proportionate increase of hemoglobin and red corpuscles In somewhat crude clinical observations at Denver, one mile above sea level, I have been accustomed to find disorders attributable to anemia in patients whose hemoglobin percentage ranged as high as from 70 per cent to 85 per cent

Gout —Gout and lithemic states are due to conditions of metabolism and circulation which are modified by climatic treatment According to Huggard, "a dry, bracing climate is always most suitable" Nevertheless, the writer is convinced that a characteristic effect of residence in high altitudes, at least in the unacclimated, is a relative venous plethora High venous blood pressure, according to good authority leads to gout Newcomers in moderately high altitudes particularly if indiscreet in exercise, are apt to suffer from "bilious attacks' as a phase in acclimatization

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contra indicates high altitudes Nevertheless, in Denver, for example, many persons with stenosis of the mitral valve live in comfort Nervous affections of the heart appear to be bettered or otherwise, in high altitudes, according to the general reactive powers of the patients

There seems no reason for believing that, in patients who lead a quiet life, *arteriosclerosis* contra indicates residence in high altitudes However, it appears that aneurism and mortality therefrom are considerably greater at high than at low elevations

Disorders of Digestion—In the writer's estimation, climate is indirectly of importance in its impress on the digestive functions through its effect on the metabolic and nervous systems

Especially in high altitudes, a "nervous dyspepsia" is apt to reflect imperfect adjustment to the environment, and a 'bilious attack," which the writer has attributed to relative venous engorgement, frequently attends the process of acclimatization.

Skin Diseases—Great importance has been attributed in the foregoing pages to the physiological functions of the skin There is no organ of the body which comes so directly under the influence of climate as the skin, yet there appears to be but a meager collection of data regarding the subject, either in health or disease Cases of *eczema* at least in its acute form are said to do badly on the seashore, and in cold, damp weather *Acne* is also made worse on the coast, and is apt to improve in dry inland stations Cases with *psoriasis* do better in a warm climate

It has been said that at high altitudes those cases do worse in which the skin disease depends on nervous derangement

Disorders of the Kidneys—It is generally admitted that the chief object to be secured in the treatment of kidney disease is rest for the organ The potent factors within our control include diet, muscular exercise and the activities of the skin and lungs Experience indicates that patients with disordered kidneys fare worst in cold, damp places of variable temperature They thrive best in warm, equable, and somewhat dry climates There is substantial basis for the opinion that persons with inflamed or degenerated kidneys are apt to fare badly at high altitudes In my experience disease contracted at an elevation is better borne than when imported It is difficult to acclimatize a diseased kidney

The observer is impressed with the importance of the circulation in renal insufficiency Clinical experience has impressed me with the belief that passive congestion of the kidneys is the preponderant deleterious factor due to the conditions of high altitude Certain forms and stages of kidney disease as of heart disease, are distinctly ameliorated by a judicious mode of life at a moderately high altitude

The Nervous System—Special emphasis has been laid in the preceding pages on the purely psychic value of climatic change The mental state is molded to a great degree by the reactions occurring in the various

organs, among which the nervous system is of predominant importance Climates may affect the nervous system either directly or indirectly through their influence on metabolism in its widest sense Using the rather indefinite terms in vogue climates may be *relaxing sedative* or *stimulating* in their influence When nutrition is improved and a state of well being secured, the qualifying term *tonic* may be added Thus, warm moist coasts or islands are sedative to relaxing On ocean voyages or cooler coasts the prevailing influence is tonic-sedative Inland places of low altitudes are usually simply tonic in effect Elevated inland regions are stimulating tonic or simply stimulating"

It has been made obvious that the physiological influence of high altitudes tends to increase the chemical activity of certain vital tissues At moderate elevations, 4,000 to 6 000 feet laying on of proteid tissue, building up of the organs, and improvement in their efficiency tend to occur With further increase of elevation katabolic processes gain ascendancy and it is as if the machine suffered from internal friction It cannot be too strongly emphasized that physiological adjustment to lowered barometric pressure requires time and rest. Imprudence in exercise on the part of newcomers is prone to turn a sojourn which might have been salutary into a period of nervous overstrain Constitution and temperament determine to an extraordinary degree the fitness of people for residence in elevated regions Persons of phlegmatic disposition or those who are nervous from malnutrition or overwork are apt to do well at high altitudes The hysterical and those with inherent nervous temperaments often find their disorders accentuated Nevertheless the medical observer is often astonished at the development of nervous stability in patients whom from a theoretical viewpoint he would have advised against seeking a high altitude The general belief that an occasional drop to sea level is necessary to the best interests of residents at high altitudes is probably well founded Differences in temperament and constitution which become especially conspicuous under the strain of low atmospheric pressure no doubt determine in a less sensible degree the adaptability of people to other climatic conditions

Though we may not accept fully Major Woodruff's dictum that in the tropics or brilliant sunlight fair skinned persons always deteriorate in health, as compared with brunettes it is nevertheless true that individual as well as racial characters determine to a degree the adaptability of climates to the preservation of health and the cure of disease

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CHAPTER V

PHYSIOTHERAPY MASSAGE EXERCISE

HARRY EATON STEWART

PHYSIOTHERAPY

Before considering in detail the different phases of physiotherapy and the proper method of blending them in the treatment of various diseases and injuries a brief survey of the subject its scope and relationship to general medicine and surgical practice is in order Physical agents have been employed therapeutically since the earliest days of medicine Heat, exercise massage, sunlight and water applied to the body were the first physical agents to be used Galvanic and faradic electricity have been used for about a century Static electricity has been employed nearly half as long while the sinusoidal and high frequency currents are of recent date The amazing speed attained in the recent development of scientific medicine has been more than matched in the field of physiotherapy by the development of modern apparatus experimentation and refinements in technic. The advance in the scientific application of physical therapeutics in the last decade is perhaps greater than that which was made up to that time The pioneers who worked in the field of electrotherapy, hydrotherapy or massage and exercise laid the foundation for the modern use of physiotherapy forming the basis for the millions of treatments given to the ex service men In the medical corps of the various armies during the Great War for the first time in the history of medicine a large number of regularly trained physicians devoted their entire time and attention to all branches of physiotherapy

In the American army we were able to institute a department of physiotherapy which functioned in sixty two different hospitals and was comprised of over a hundred physicians and twelve hundred reconstruction aides The personal backing of the Surgeon General and the organization of a department of his office under Lieutenant Colonel Frank B Granger of Boston brought together a personnel and equipment the like of which had never before existed From 1918 to the end of 1922 millions of physiotherapy treatments were given to the service and ex

service men by the medical departments of the Army, Navy, U S Public Health Service and Veterans' Bureau The results on the whole were extremely gratifying and by reason of the vast amount of data collected we may feel that physiotherapy is on as firm and proved a scientific basis as any other branch of medical practice

The scope for the application of this branch of therapy has rapidly widened until at the present time a large proportion of diseases and almost all types of injury are amenable to treatment by it *It cannot be too strongly insisted upon that with a few minor exceptions physiotherapy*

FIG 1—A WELL EQUIPPED ELECTROTHERAPY ROOM

is not a complete regime of treatment but is an adjunct to the routine hygienic medical and surgical care of the patient Fortunately there are practically no contra indications to the employment of the accepted methods in combination with physiotherapy in any given case Long retention of fixation apparatus is perhaps the main exception Physiotherapy is directly applied to the affected part It requires a large amount of detail in the technic of its employment The large floor space and special apparatus required to do the best work places a limitation upon the amount of physiotherapy which the general practitioner can do conveniently Nevertheless, it is vitally important that he be able to determine those conditions in which the help of physiotherapy will lead to more rapid recovery on the part of his patients A full equipment is

for the specialist and the hospital department of physiotherapy both of which are now rapidly increasing in number On the other hand, a great deal of good may be accomplished with a comparatively simple equipment providing the indications and principles underlying the technic are thoroughly understood Even a good piece of apparatus and the manufacturer's direction as to its use are not a sufficient background for practice in even a single branch of physiotherapy

A digest of the main modalities used and indications for the employment of physiotherapy will exemplify the widening scope of this branch of treatment The electrical currents are employed in accordance with their three main effects on living tissue first, changes in chemistry second, mechanical action and third the production of heat In the first division falls the straight *galvanic* current and we use it to rearrange the ions within the tissues to drive in drug ions from without, to destroy tissue by their caustic concentration and to allay nerve pain In the second group are found the *interrupted* and *wave galvanic* and *sinusoidal currents* used for the contraction of muscle completely or partially deprived of its nerve supply, and to stimulate other functions by muscular contraction.

Faradism is used to restore the tone of underfunctioning muscles whose nerve supply is normal *Static* electricity in the form of the Morton wave sparks and effluve is employed to produce mass or local tissue contraction for glandular stimulation or the removal of lymphatic stasis, and to alleviate pain due to the pressure of such stasis The high frequency currents of *Oudin* and *Tesla* produce superficial and to a certain degree deep heat relieve pain and stimulate metabolism or destroy by fulguration when localized at a needle point *Diathermy* which is one of the most powerful agents in all the field of medicine creates an intense deep-seated heat localized at will with a subsequent active hyperemia which greatly reduces repair time and aids in the resistance to localized infection Its general effect in lowering hypertension decreasing pain and promoting general and local metabolism is also made use of

Radiant light and heat stimulate the circulation relieve pain and promote repair

Ultraviolet light has both a local and general effect. Locally it is one of the most powerful of antiseptics with no effect upon the host other than the destruction in strong doses of superficial epithelium Most localized infections yield readily to its application in their early stages In moderate amounts it is a very powerful stimulant to skin cell growth and is indicated in slowly healing wounds and ulcers of the skin Generally, it is the same tonic to the body that sunlight is enriching the hemoglobin and the fighting property of the blood increasing metabolism and inducing sleep

Exercise and *massage* develop the body and its nervous coordinations,

stimulate metabolism, defer tissue deterioration in middle life, aid circulation and help to prevent and reduce deformity

Hydrotherapy may be used to induce reflexly both stimulation and sedation of the nervous system and obtain both local and general changes in the circulation

The time when the term physiotherapy meant "baking and massage" is over, so is the real usefulness of an assistant whose methods are limited to these two means

Requirements for Hospital and Clinical Departments of Physiotherapy

The government hospital department of physiotherapy has served as a model for a number of such departments recently established in civilian general hospitals

Personnel —The type of young woman who became the reconstruction aide of the war and post war days had, as a rule, normal school, college or nursing training and received intensive courses in all branches of physiotherapy There are several schools of physiotherapy graduating well trained aides and they are becoming available in increasing numbers There should be one aide for each four to eight nurses, depending on the type of cases handled

Floor Space —A great deal of work can be done in a relatively small space if it is properly arranged There should be many wall plugs, divided into several separate circuits The intake wiring and fuses should be very heavy If the tables (or cubicles) are arranged parallel, with four feet between them and the side wall, much of the apparatus may be conveniently shifted to the various tables or stalls All circuits should be numbered in the fuse boxes to facilitate quick replacement of fuses when blown out

Apparatus —A small department for a hospital of one hundred beds would require at least the following apparatus eight treatment tables, two sets of pulley weights one galvanic control, one faradic coil, one sinusoidal machine, one air-cooled ultraviolet lamp with a few quartz applicators for local work, four small portable or two 1500 candle power radiant lights two portable and two stationary high frequency machines In a two hundred bed hospital, this equipment should be doubled except that a water cooled ultraviolet lamp instead of a second air-cooled should be added, together with a motor vibrator, static machine and paraffin bath Care should be taken to state the type of current, frequency and voltage in ordering machines In larger hospitals and those devoted to special types of cases, this equipment would have to be greatly modified A corrective gymnastic room and hydrotherapy plant are most useful where it is possible to install them

Post war Reconstruction.—The writer after his work as assistant director of physiotherapy of the army section, organized the section of physiotherapy in the Bureau of the United States Public Health Service which took over the care of the disabled ex-service men. This work has grown during the last four years to a magnitude equaling that done by the Army Medical Corps and has now been transferred to the Veterans Bureau. In the meantime the Public Health Service has continued and extended this work among its own Marine Hospitals, and the Navy has also established this branch of its medical service on a good basis. The longer these hospital departments have functioned the more invaluable have they proved themselves. With the ex-service men the work, now largely with chronic diseases, has fallen into three main types. *First*, the neuropsychiatric cases which include peripheral nerve regeneration, traumatic psychoses of various types, and a wide variety of other conditions. All types of physiotherapy are employed in the treatment, but hydrotherapy takes a more prominent place than it does in the general hospital. *Second*, the tuberculous group often complicated by war wounds and various other conditions. With this class of cases, ultraviolet light is of great importance although all methods are employed. The *third* type is the general medical and surgical group which requires a well rounded application of physiotherapy. It is certain from the results obtained that physiotherapy will have an increasing role in the treatment of these conditions until the chapter is closed. Those in charge of departments in general and special hospitals can learn much from what has been accomplished by the adequate, thorough and persistent application of physiotherapy to a wide range of conditions under government supervision.

Industrial Accidents.—There have lately been established in rapidly increasing numbers clinics and hospitals devoted entirely to the physical rehabilitation of the injured workman. Physiotherapy and prescribed occupational therapy with vocational training form the backbone of their work. It is a matter of great economic importance to the worker, his family, his employer and the compensation insurance companies that he be returned to functional efficiency and full earning power at the earliest possible moment. Once the initial surgical care has been properly performed, main dependence for this early return of function must be placed on physiotherapy. Nothing else can be substituted for it. The recovery time in fractures can be reduced by about one-third. In cases of sprains and bruises an even greater reduction in recovery time is possible. The cost of special treatment or of maintaining a department of physiotherapy is much less from an economic standpoint alone than is the payment of compensation through an unnecessarily long period of disability. There is no question that in this particular field physiotherapy will make one of its most valuable contributions to medicine.

Athletic Injuries.—It has been conclusively demonstrated in the treatment of the injured athletes of some of the larger university teams during the last three years that physiotherapy properly used greatly cuts down the time of disability during which athletes have lost their usefulness to the team. The sprains, strains and muscle bruises which make up a large part of athletic injuries are especially amenable to physiotherapeutic treatment. The danger of permanent disability or recurrent injury through chronic weakness is markedly lessened. The prescribing of the treatment must be in the hands of the team physician and not the athletic trainer.

General Hospital Practice.—It has been said that "no hospital can call itself modern in these days unless it has a good department of physiotherapy." That statement is subscribed to by practically all physicians and surgeons who have had the opportunity to watch such a department function. Occasionally in the government services, the medical officer in charge of a hospital has been reluctant to assign the space and undertake the expenses incident to the establishment of a hospital department. Practically without exception those medical officers have become enthusiastic in their support of their physiotherapy department. They have come to the conclusion that the average number of hospital days has been sufficiently reduced in the case of patients treated by physiotherapy to more than compensate for the expense and the space necessitated by its installation.

Medical School Curriculum.—Only a few of our medical schools have as yet placed physiotherapy in the course of study. A reviewer of the *Journal of the American Medical Association* in a recent comment on a new text on this subject stated, "The subjects are generally studied inadequately or not at all in medical schools. One of the excuses given for the neglect of these important topics in the medical school has been the lack of a suitable textbook. Unfortunately the real cause for the neglect of physiotherapy is the ignorance of the framers of medical school curriculums regarding it. As the students of the present become the curriculum makers of the future, we have here a vicious circle."

There are many well qualified teachers now available and there is no longer adequate excuse for the neglect which the medical schools have shown in instructing their students in this important subject.

The object of the section termed Applied Physiotherapy (Chapter XII) is to show the proper blending of the various modalities described in Chapters V to XI in the treatment of those phases of injury and disease in which these measures have proved of value. Very little has appeared so far in the literature on the use of more than a single type of physiotherapy in a given condition. The author of a textbook on Hydrotherapy treats of the application of that phase alone and gives an appended list of pathological conditions in which it is useful. The same

is true of authors of texts on Exercise and Massage or upon Electrotherapy. It is felt that an outline of the properly combined use of the different types of physiotherapy indicated in any given condition will prove of great value. *It must be thoroughly understood that the writer is dealing with physiotherapy as an adjunct to the indicated hygienic, medical or surgical procedures in every given case,* and it is taken for granted that these measures have been determined upon and instituted in conjunction with the physical therapeutic measures here outlined. In the more common conditions met with, an ideal treatment presupposing the use of a complete equipment will be considered, and where possible a simplified technic will be added which requires but little apparatus.

Through choice, a large number of conditions in which types of physiotherapy have been used, but where the results have not been uniformly of value, have been omitted. Success in using physiotherapy is dependent as much upon a thorough detailed knowledge of the proper technic as it is in any other phase of therapy. The work and research now being done in the field will undoubtedly rapidly widen the known indication for its use. The physician and surgeon now have at hand an adjunct of increasing usefulness in the field of therapeutics, and one which will richly repay them for time spent in careful investigation.

MASSAGE

Definition.—Massage is the scientific manipulation of the soft tissues of the living body for therapeutic purposes. It modifies both the physiological and pathological tissue processes by mechanical means.

History.—Many centuries before the Christian era the Chinese were probably the first to use massage. In India, Japan and Arabia the use of this method of treatment is very old. It was used for therapeutic purposes by the Greeks and testimony as to its value in certain conditions can be found in the writings of Hippocrates. The Romans employed massage in connection with their baths. Galen used it with the gladiators in preparing them for combat.

Paré in the sixteenth century recommended massage and passive motion in disabled joints and many other conditions. A little over a century ago the French extended its use and gave their terms to the various movements into which the manipulation became divided. To Grovesnor of England, Balfour of Scotland and Ling of Sweden we owe the placing of massage upon a scientific basis. Particularly are we indebted to Ling, his son and successors in the Royal Central Institute of Stockholm for the proper correlation of exercise with massage. During the last half of the nineteenth century Mezger of Amsterdam, Weir Mitchell and J. H. Kellogg of America were instrumental in gaining the recognition of the

profession to the value of massage, until at present the wide therapeutic indications for massage have general recognition

The widening scope of other phases of physical therapeutics has clearly demonstrated the fact that there are other and better means of fulfilling some of the indications for which massage has been formerly used However, for certain results no substitute will serve as well

In modern therapeutics, massage is usually blended with other types of physiotherapy and takes an important place in such combinations of treatments

FIG —EFFLEURAGE OF THE FOREARM (Courtesy Paul B Hoeber)

General Considerations—The physician with his background of anatomy, physiology and pathology may acquire sufficient knowledge to prescribe massage intelligently in a very short time The amount of practice necessary for him actually to give a treatment with reasonable skill is not great While few physicians are able personally to do their treatment work, the knowledge *acquired in learning how to do it* well will be invaluable in estimating how skillfully their prescriptions are carried out The rubbing of the Turkish bath attendant and the manipulations of the athletic team "rubber" have very little relation to scientific massage, nor is the efficiency of the average treatment in direct proportion to the amount of physical energy that the masseur expends, upon the patient

There are three distinct schools of massage, the English, Swedish and

Hoffa The best work is done by those whose knowledge of anatomy, physiology and pathology is greatest and who have made a careful study of all methods, blending the best of each and evolving their own personal technic It is well to watch carefully one who claims to be proficient in any *one* of these schools The attitude of the masseur should be sympathetic and friendly, yet detached and businesslike for it is only through absolute confidence on the part of the patient that he is able to relax completely and best results be obtained No jewelry should be worn on the hands of the operator, nor any sleeves below the elbow Only the part of the patient's body under treatment should be exposed The part being massaged should be supported The temperature of the rooms should be from 70° to 75 F Where much massage is to be done it is necessary to have an especially constructed table which should be about 2 feet wide and 32 to 36 inches high A solid table covered with a good mattress is to be preferred to springs of any kind In our army the reconstruction aides very often discovered during their massage the presence of foreign bodies and changes in the condition of the parts These they were encouraged to report to the physician, but changes in technic of treatment were not and should not be allowed without the physician s orders It must be remembered that we are dealing with a potent agency when we are applying massage to patients The physician should no more order massage for a given condition without stating the type and the amount than he should order drugs without stating the kind and the dosage Massage may be used for diametrically opposite purposes to soothe or to stimulate, and must, therefore be minutely prescribed if the treatment is to be beneficial

Most masseurs use some kind of a lubricant on the hands Cold cream cocoa butter, vaselin and olive oil have all been used for this purpose The first is perhaps the best for general use and should be removed from the skin with alcohol There is a general tendency to use too much lubrication It is impossible to produce good friction with any lubricant Powder is being used more extensively and is preferred by many The use of stimulating liniments or icthyol in any form for counterirritation is of no use to the patient, and it may seriously affect the hands of the operator

The length of time of a treatment depends on many factors A local treatment of from five to ten minutes is sufficient as a rule when combined with other physical agents In the treatment of a single part where massage alone is used fifteen to twenty minutes may be employed In a general treatment, which should take about an hour the relative number of minutes given each part should be approximately as follows legs fifteen, arms, ten chest five abdomen fifteen back fifteen Such general treatments should be given not sooner than an hour after eating and a short period of rest following the treatment is advisable The severity

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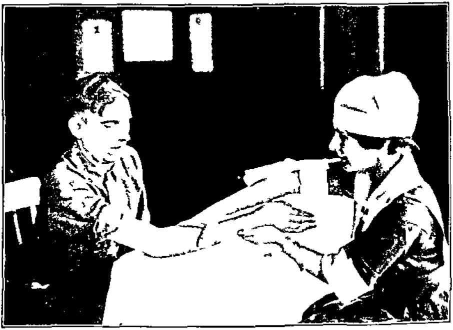

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in the direction of the venous or lymphatic flow It is done lightly for superficial effect more deeply to affect the circulation of underlying tissues Where possible the hand or fingers are kept in contact with the part returning very lightly to the starting point of the stroke The pressure is usually slightly greater in the mid part of the stroke than at the beginning and end of it Effleurage should be slowly done perhaps twenty to thirty strokes per minute on the average It is a general rule for the movement to be carried beyond the next proximal joint It is of great importance to train the hands to equal skill so that they may be used alternately or simultaneously with the same deft touch In full hand stroking the fingers should be held lightly together

The *physiological effects* of effleurage are perfectly definite In light stroking the sensitivity of cutaneous nerve endings is lessened there is a slight diminution in the skin circulation and diminished activity of the skin glands In deeper stroking the sedative effect is not as marked There is a slight increase of the skin circulation and activity of its glands and a marked effect on the returning circulation in the veins and lymphatics This aids in the removal of extravasated blood and lymph, and accumulated fatigue products

Petrissage (pinching or kneading) is perhaps the most valuable movement of massage and should therefore be thoroughly mastered Like effleurage the operator uses a portion of the hand comparable to the size of the tissues to be kneaded On the muscles of the hands and face the tips of the thumbs and first and second fingers are used for picking up rolling and twisting the finer muscles In working on a single finger or toe use the tip of the thumb and first finger of one hand one placed laterally, the other anteroposteriorly In muscle groups the size of those in the arm the grasping is done with the entire surface of the fingers and thumbs mainly by flexion of metacarpophalangeal joints In grasping larger muscle masses the entire surface of both hands is used parallel and the muscle fibers grasped transversely In many regions particularly on the back the muscles are rolled and kneaded against the bone In the arm and lower leg the muscle groups are grasped between the thumb and fingers starting distally with alternate grasping and relaxing and working in a proximal direction Skillful operators often develop a slight twisting movement with the hands which is an aid in thorough kneading On the abdomen where we are unable to pick out the various muscle layers the kneading is done in concentric circles deeply enough to reach lower muscle layers *In the gluteal region there is considerable* dense fascia and the kneading should be deep enough to reach the muscle groups

The *physiological effect* of petrissage is to stimulate both motor and sensory nerve endings increasing muscle tone in proportion to the vigor of the treatment within reasonable limits of time Fatigue and toxic prod

of the treatment and the relative proportion of time given to the different types of manipulation are determined by the object in mind

Types of Movements—There are five main movements used in massage

1 Effleurage or stroking
2 Petrissage (pinching or kneading)

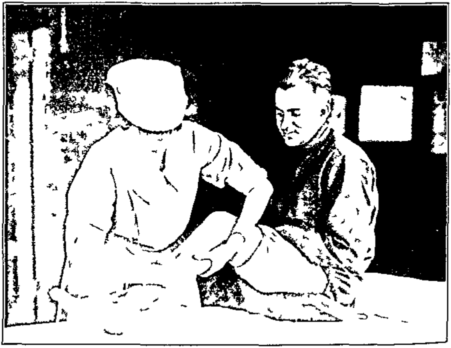

Fig 3—Petrissage of Calf Muscle (Courtesy Paul B Hoeber)

3 Tapotement (hacking, slapping or percussion)
4 Friction
5 Vibration

Effleurage or stroking may be done by the entire palmar surface of both hands, used simultaneously or alternately In stroking medium sized surfaces such as the arm or the lower leg the fingers and inner surface of the thumbs are used with a firm but flexible grasp which accommodates itself to changes in the contour of the part In still smaller surfaces like the Achilles' tendon, the thumb and first finger only may be used Between the interossei on the back of the hand, the tips of three fingers, or the tips of the thumbs are used also in both straight and spiral stroking of the fingers or toes All stroking is done slowly and with the exception of the special technic for amputation stumps, later to be described,

in the direction of the venous or lymphatic flow. It is done lightly for superficial effect, more deeply to affect the circulation of underlying tissues. Where possible the hand or fingers are kept in contact with the part, returning very lightly to the starting point of the stroke. The pressure is usually slightly greater in the mid part of the stroke than at the beginning and end of it. Effleurage should be slowly done, perhaps twenty to thirty strokes per minute on the average. It is a general rule for the movement to be carried beyond the next proximal joint. It is of great importance to train the hands to equal skill so that they may be used alternately or simultaneously with the same deft touch. In full hand stroking the fingers should be held lightly together.

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The *physiological effect* of petrissage is to stimulate both motor and sensory nerve endings, increasing muscle tone in proportion to the vigor of the treatment within reasonable limits of time. Fatigue and toxic prod

ucts are mechanically removed, together with extravasted blood and lymph The capillary circulation is made both more rapid and greater in volume, and the venous and lymphatic circulation markedly quickened This procedure is contra indicated in conditions of muscular hypertension and spasticity, and should be done lightly with a minimum length of time in muscles having a deficient motor innervation This stimulating effect on the general metabolism of muscle tissue is similar to, but not as efficient as, that obtained by active exercise It can be used as a substitute for such exercise where muscle contraction would displace the fragments of fractures or bring strain on torn ligaments

Tapotement includes slapping cupping, hacking and percussion

Slapping should be performed with the palmar surface of the fingers, by quick, light, alternate strokes, wrist relaxed, and the fingers or whole hands immediately rebounding from the skin surface At no time should the stroke be heavy or the hand remain upon the skin By this technic the sensory nerve endings are acutely stimulated, the superficial capillaries widely dilated, and there is a reflex general stimulation produced on the entire nervous system

Cupping is done by the hands, with fingers and thumbs held tightly adducted and with a slight flexion at the metacarpophalangeal joints The blow is somewhat heavier and while not remaining on the skin, it has not the instantaneous rebound of proper slapping The effect of cupping is somewhat more intense and deep seated than that of slapping, but accomplishes much the same results

Hacking may be given lightly or very heavily, depending upon the manner in which the hands are held, and the vigor of the blow In both types, blows are struck with ulnar side of the hand, and little finger The movement is performed by rapid alternating adduction of the wrist joints, coupled with slight supination of the forearms In light hacking, the fingers are relaxed and slightly separated and strike the body, the little finger first and the others in succession The blows alternate with extreme rapidity and with a rebounding character, resembling that described for slapping This movement is easier to acquire if the elbows are semiflexed and held somewhat out from the body It is one of the most difficult movements in which to obtain skill and necessitates considerable practice In heavy hacking the fingers are held in adduction and rigid, the wrist more rigid, the blows given more heavily and slowly The therapeutic indications for the employment of hacking are the relief of muscle spasm of local toxic or traumatic origin, especially in the chronic stage, the breaking up of organized exudates within the tissues, the vigorous stimulation of the circulation in large and deep-lying muscle masses, with consequent stimulation of the metabolic changes within them

Another method of hacking, sometimes termed beating, may be employed in dense tissues, such as the gluteal region In this type, the fists

are tightly clenched and the body hit with the dorsal surface of the second phalanges of the fingers, by a combination of extension of the elbow and flexion of the wrist. The physiological effect would be the same as that of heavy hacking.

Percussion may be done lightly by striking the back of the index finger, distal joint, with the index finger of the right hand in exactly the same way that it is employed in physical diagnosis. For heavier effect the finger or fingers of one hand may be struck by the ulnar side of the clenched fist. A light slow rhythmic percussion is soothing in its effect upon nerves lying within the area reached, and conversely heavier percussion is stimulating to them. To a certain extent the viscera supplied by spinal nerves may be effected by percussion along the spine in the region from which they are innervated. A similar effect may be secured at the point where peripheral nerves exit through certain foramina.

Friction is given by the use of the tips of the fingers and thumbs or the thumbs alone, placing them on the skin and moving the skin over the subcutaneous tissue, with varying degrees of pressure. The movements are nearly always circular in type and as before stated no lubricant should be used, for this causes the fingers to slip on the skin and makes good friction impossible. In small areas, such as the hands and wrist, the thumbs and fingers may be used simultaneously with opposed grasp while on large flat surfaces it is more convenient to us the thumbs with their pulps describing opposite small circles. On small joints such as those of the phalanges, the thumb and one finger of both hands may be used simultaneously. When a sufficient number of frictions that is six to twelve are performed on an area the fingers or thumbs are raised and placed in a new position and the procedure repeated until the entire area to be affected has been covered. The indications for the use of frictions are to break down adhesions, soften scar tissue remove extravasated material from around joints and tendons and to reduce soft exuberant callus. In moderately large swellings the movement should be first around the periphery and then toward the center.

Vibration is accomplished as a rule by the application of one or more finger tips to the skin, although the palm of the hand or a portion of the clenched fist may also be used. A rapid tremor is effected by the action of the muscles of the entire arm to the shoulder joint. The effects produced resemble those of percussion and are used for practically the same purposes. Prolonged light vibration will effect a numbing of a superficial nerve while powerful deep vibration will stimulate. The direct stimulation of the abdominal viscera is possible by applying this method to the abdomen.

General Effects.—The detailed descriptions of the various movements given above should enable the physician to combine certain of them for his desired therapeutic result.

General Indications.—Massage in some form is indicated in most inflammatory processes in their subacute or chronic stage, whether toxic or traumatic in origin, thus assisting in the local removal of effete material from the tissues.

In atrophic muscle conditions, from whatever cause.

To increase metabolism both general and local.

To stimulate the activity of the skin glands.

To reduce the amount of scar tissue and callus.

To increase the lymphatic and venous circulation.

For sedative effect on the sensory nerves, and consequent promotion of sleep.

To ascertain and aid in the removal of foreign bodies, such as fine shrapnel, shot or small pieces of necrotic bone in chronic cases.

Contra-indications.—Malignant tissue, or swellings which might by any chance be malignant, should never be massaged until a definite diagnosis is made. Neither should massage be given in the following conditions:

Acute inflammatory processes.

Acute skin infections.

Acute disease accompanied by fever.

Acute phlebitis and thrombosis.

Lymphangitis of local acute inflammatory conditions.

Osteomyelitis, gastric or duodenal ulcers and marked degrees of hernia.

General Massage—Regional Technic

In a general body treatment the proportionate time given the various parts of the body has already been stated and is simply added for a complete treatment. There remains to be given the manner in which the various movements are blended in a thorough massage of the different regions of the body. It is customary for many masseurs to use passive movements in connection with massage. These joint movements are given, as a rule, just before the final stroking, the distal joints first, and in each case, if possible, the joint is moved through its entire normal range of motion several times.

Passive motion belongs properly to the subject of exercise, and is described more fully in that chapter. Facial and head massage is not included in the routine general treatment.

The Arm.—Many operators begin on the fingers and hand with all the indicated movements, and work centrally. Some have felt that it is more advisable to work first on the proximal, then on the middle and lastly on the distal main segment of the limb, movements in each region being directed centrally. In this manner the lymphatic and venous cir-

culations are depleted by natural stages This same effect may be obtained by preliminary deep stroking The stroking is carried from just below the elbow to over the shoulder cap using opposite grasp of the anterior and posterior muscles, with moderately firm pressure The forearm is manipulated in much the same way the strokes running from just below the wrist joint to slightly beyond the elbow Six or eight repetitions of fairly long deep slow strokes are sufficient to accomplish this result We may then start as is usual with the fingers

The fingers and thumbs are worked on rapidly, covering their entire surface about twice with alternate pinching tirting anteroposteriorly and laterally, followed by spiral stroking This is done by using the tips of the fingers and thumbs The thenar and hypothenar eminences are petrissaged and frictioned followed by finger tip stroking between the interossei on the back of the hand The wrist is then frictioned anteriorly and posteriorly The fingers and thumbs are next rapidly flexed and extended passively several times followed by circumduction of the thumb, after which the wrist is moved through its full range of motion

Petrissage of the forearm is given by opposite grasp with ascending circular kneading the right hand slightly ahead of the left, and carried to the muscle origins beyond the elbow joint If preferred one hand can be used alone, the other supporting the patient s hand Tapotement may be lightly given, but is usually omitted in muscle groups as small as those in the forearm and arm A few slow deep effleurage movements complete the work on the forearm With the elbow semiflexed the joint is worked on with finger tip friction both anteriorly and posteriorly, followed by passive motions of flexion extension pronation and supination of the forearm

Petrissage of the arm is directed first upon the anterior and then upon the posterior muscles, with the right hand alone or the hands used parallel to each other The extensors of the elbow are best reached by flexing the patient s arm across his chest This is followed by slow deep effleurage, carried over the shoulder and frictions entirely covering the shoulder joint A number of long rapid light strokes from wrist to shoulder complete the massage

The Leg — A few slow deep strokes of the thigh leg and foot in order, are first given Then the toes are stroked singly or together Thumb friction and finger stroking is done over the dorsum of the foot the outer border and very thoroughly over the arch The petrissage and stroking of the lower leg is aimed at picking out the tibialis anticus peronei and calf muscle group and must be deeply and well done to reach the deeper lying and heavier posterior muscles Passive motion of the toes foot ankle and knee are given followed by full hand petrissage and deep stroking of the muscles of the thigh Long slow stroking from foot to thigh completes the treatment. Tapotement may be used over the calf

muscle group, in both the anterior and posterior thigh muscles, with careful friction over the knee in the popliteal space

The Abdomen—The general object of abdominal massage is to stimulate *peristalsis and the movement of the intestinal contents*, *to stimulate* the activity of abdominal glands, to stimulate the muscles of the abdominal wall The patient should be supine and have the knees raised and supported to acquire proper relaxation Where there is tenderness in the region of the gall bladder or appendix and during menstruation and pregnancy, abdominal massage is contra indicated

The palmar surface of the hand is held adducted and hyperextended and all kneading is done in a circular manner One hand may be used alone, or for deeper effect the other hand placed directly on it, increasing the applied pressure It is common to start in the region of the cæcum performing two or three deep kneading movements, then replace the hand in a slightly higher position, repeating by following the course of the colon To reach a proportion of the small intestine, circular kneading is extended in concentric circles until the entire abdominal wall is covered Gentle, springy, alternate pressure and relaxation over the liver, and abdominal viscera is used for direct stimulation For the removal of flatulence the whole hand may be vigorously percussed with the palm of the other hand or the clenched fist over the hepatic and splenic flexures of the colon, and over the stomach Gentle stroking with the hands spread, starting high on the flanks and converging toward the groin, is used in completing the treatment

The Chest—Place the thumbs at either side of the sternum and knead and friction toward the axilla in the first intercostal space, deeply enough to effect the intercostal muscles through the pectorals Friction and knead the clavicular and sternal origin of the pectoral muscles The outer half of the pectoralis major is thoroughly kneaded by the finger tips in the axilla, and the thumb over the front of the muscles, or better still by the finger tips of one hand above, the other below the muscles, performing a circular kneading Finish with effleurage toward the shoulder tip

The Back—The patient is placed prone and an effort made to relax completely the erector spinæ muscles by placing a small pillow under the chest and thighs This may be more ideally done by an adjustable hammock frame similar to the Bradford frame Effleurage of the entire back with both hands simultaneously may be used, stroking the outer regions of the back upward and outward to the shoulder cap, the neck and upper part of the trapezius from the occiput downward and outward to the point of the shoulder This is followed by strokes beginning at the neck and continuing downward close to the spine, allowing the hands to separate at the sacrum, and pass to the outer point of the hips A series of frictions, both hands working simultaneously, on either side of the spine and parallel to it, thumbs meeting at the spinous processes, may be given

starting from the neck and working down to the sacrum repeated several times. Thorough kneading is then done, the hands placed parallel, working on the muscles of the neck on one side and following the trapezius fibers to the shoulder then on the opposite side followed by the supraspinatus, infraspinatus, rhomboids, erector spinæ and other groups separately. The erector spinæ must be worked on deeply with the tips of the fingers and thumbs. Light tapotement over the heavier groups of muscles and down the erector spinæ is added where stimulating effect is desired. The treatment is completed by a thorough repetition of effleurage.

Summary

There are certain salient facts in regard to massage and its use in therapeutics which it might be well to review in closing. We are not dealing with a single entity in massage but with a number of different manipulations upon the body which in themselves have distinctive physiological effects. These differences may be further emphasized by the manner in which they are given as regards skill force duration and repetitions of the movement. If the underlying principles have been made clear the physician should be able to prescribe or perform suitable massage wherever the employment of any phase of it is indicated. Such intelligent choice of type and amount is of greater value to the patient than any degree of technical skill on the part of the operator. There has been on the part of the profession too great a tendency to place reliance upon the technical skill of masseurs, grounded in some one school or system. Increased care in the details of the prescription for massage to patients and its proper correlation with other phases of physiotherapy will greatly enhance its value in the field of therapeutics.

EXERCISE

Exercise is one of the fundamental body processes, and ranks with food, rest elimination and respiration in the importance of its relationship to health. Modern civilization has modified exercise more than it has any other fundamental phase of human life. It will be shown that the efficiency of the body as a machine is to a very large extent dependent upon the efficiency of the muscular system. Every other important system in the body nervous glandular, respiratory, circulatory and even osseous is profoundly influenced by the activity or non activity of the skeletal muscles. Too much consideration therefore cannot be given by the physician to this important subject. His advice if intelligently and faithfully followed will increase the efficiency of the average individual prevent illness and deformity and he has at his command a powerful

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ion concentration in the blood passing through the respiratory center, and by nervous impulses of central origin which increase the sensitivity of that center

Under normal rest conditions the *output of the heart* is about 3,000 or 4,000 c c of blood per minute In extreme muscular effort this amount may be increased to almost 20,000 c c Diastole is a passive process depending on the volume of venous return flow During active exercise this return flow is augmented by the increased mechanical pressure exerted on the veins by the contracting muscles and by the increased rate and degree of the pumping action of the diaphragm The physiological limit to the diastolic enlargement of the heart is reached when the pericardium is filled

Pulse rate acceleration is dependent upon the time it takes to fill the auricles The main factor in determining the total output of the heart is the quality of its muscle fibers The rate of contraction is increased by impulses from higher centers to the vagus center lessening the tonus of the heart fibers At the same time the accelerators are stimulated The maximum pulse rate is about 165 beats per minute in both trained and untrained individuals The relative efficiency of their hearts depends on the amount of blood per beat that the contractile power of the heart is able to drive into the aorta The net working power of the heart is decreased if the pulse rate is raised without increasing the total output per minute or if its dilatation goes beyond the physiological limit

Increased *local blood supply* to the muscles is obtained by increased blood pressure constriction of the vessels in the splanchnic area and the dilatation of those within the muscles themselves It may reach from six to eight times the amount of the circulation during rest

Oxygen is supplied to a working muscle in greatly increased amounts Double the usual amount is withdrawn from the blood The increased concentration of the hydrogen ion leads to more rapid dissociation of oxyhemoglobin, raising the oxygen tension in the blood plasma and aiding its passage into the muscles The heart itself demands many times its usual supply of oxygen which is supplied by the coronary circulation

During violent exertion many parts of the body *act as a unit* to supply the requisite power The impulses to motor activity are usually instituted by the motor centers of the brain Impulses to the medulla increase the respiratory rate and raise the blood pressure Later the increased hydrogen ion concentration helps to sustain effort The impulses from the central nervous system are greatly increased under emotional stimulation which enables the heart to draw on its reserve power, beyond that emotional stimulation has no effect The role of the internal secretions especially adrenalin is probably small in increasing immediate working power

Training increases efficiency in many ways It is accomplished by

therapeutic agent in the treatment of many pathological conditions, which may already be present

In professional and business life the amount of exercise taken by the average person is almost nil, while the skilled trades are requiring the management of intricate machinery rather than manual work Both mental application and the use of finer muscle coordinations are a drain on the stored nervous energy of the body Reasonable use of the larger muscle groups, on the other hand, has the effect of increasing ultimately the body's reserve power

Physiology of Exercise—A brief review of the more important facts in the physiology of exercise will tend to emphasize the far reaching effects it has throughout the body We are too apt to consider the subject from the standpoint of the skeletal muscles alone The reader is referred to texts, such as that of Bainbridge, for greater detail Muscle power demonstrates the body's efficiency as a machine The active coordination of the entire nervous system and the cardiorespiratory system are essential in all vigorous exercise Such coordination is not essential and does not occur in any form of passive exercise or massage The energy for muscle work is developed in the muscles themselves, and they transform potential into kinetic energy, and then renew their store of potential power during rest The liberation of energy in a working muscle is probably a non oxidative process Oxygen is necessary to replace potential energy, which must be obtained ultimately from the oxidation of the food brought to the muscles by the blood Exercise increases the demand of muscle for nutrition and oxygen During severe physical exertion, the muscles consume from five to ten times the amount of oxygen that they use during rest To supply the oxygen, increased activity of the respiratory system is essential We have the increase of heart rate and vigor of contractions, rise in blood pressure increased depth and frequency of respiration, and activity of the central nervous system, all these being an essential concomitant of exercise

The *available energy* for muscular work is derived almost entirely from carbohydrates Some of it comes from fats under certain conditions, but practically none from protein Later protein probably plays an important part in rebuilding the potential energy of the muscles Lactic acid appears during muscular work, and the hydrogen ion concentration is probably vital to contraction

The *efficiency of the body* considered as a machine is rather low It varies from 20 to 33 per cent, depending on many factors such as training, speed of the movement, especially in relation to the so-called "natural rhythm" climate and fatigue

The *oxygen consumption* during exercise varies directly as the amount of work and the degree of pulmonic ventilation, other conditions being equal Greater aeration of the lungs is induced by the increased hydrogen

of functional and organic injury The pericardium may become enlarged *with the heart and permanently lowered efficiency of the heart result* making muscular exertions either dangerous or impossible

Physical Education—There is a present and growing world wide interest in physical training This is due to many factors some of which are

The deplorable physical condition of nearly one-third of our manhood as revealed by that first national health census the recent draft examinations for the army

The realization that a soldier is no stronger than his heart, or the muscles and ligaments of his feet and back

The intensified interest in athletic competition for both boys and girls

The fact that in becoming a city dwelling nation we are reducing beyond the limits of safety the play space of our children.

The intensive study of industrial fatigue and its relation to efficiency

The fact that early physical deterioration and premature death is causing *the loss to the country of the services of too many of its business and* professional men when they should still be in their prime

Types of Exercise—The advice of the physician is constantly sought regarding the type of exercise suitable to various conditions the possible dangers of athletics and how to safeguard the participant from them

The general practitioner cannot be expected to be familiar with all the phases of physical education which is becoming in itself a specialty of medicine However, with an adequate knowledge of the physiology of exercise and of some of the conclusions arrived at by those in this specialty the physician should be able to give intelligent advice to patients on exercise problems

Exercise falls largely into the following types speed, strength, endurance, skill and corrective The last will be discussed under the heading of orthopedic and medical gymnastics

Exercises of *speed* in which a given distance is covered in the shortest possible space of time, are suited to all ages up to thirty five provided the distances for children and adolescents are materially cut down Illustrated by sprint running this might be a safe rule allow up to twelve years 40 yards, twelve to fifteen years 75 to 100 yards fifteen to eighteen up to 220 yards depending on training and condition

Exercises of *strength* such as weight throwing gymnastic apparatus work and wrestling are those which require every ounce of one s energy to perform They are best adapted to the ages of sixteen to forty years carefully graded for the immature

Exercises of *endurance* are composed largely of many relatively slow and rhythmical repetitions of movements easy in themselves, such as distance walking running skating dancing and swimming and certain team games with long playing periods They are suitable to any age

a steady and gradual increase in the amount of exercise taken Diet, sleep and other factors aid The heart and the diaphragm are developed simultaneously with the skeletal muscles During severe exertion the trained individual maintains a lower blood pressure and pulse rate and the amount of physiological dilatation of the heart is less than in the untrained During rest also his pulse is slower, but the heart's output per beat is greater than in one out of training The increase in the oxygen-carrying power of the blood, strength of respiratory muscles better coordination of muscles and keener judgment of the degree of effort required, all work to the advantage of the trained person

Second wind—that relief from distress shown by distance runners after part of the race has been run—is believed to be due to a fall in the alveolar tension of CO and a decrease in the necessary amount of pulmonic ventilation from a decreased hydrogen ion concentration in the circulatory blood

Fatigue is a lessened capacity for performing work accompanied by several subjective sensations The feeling of fatigue and its actual presence are not always the same thing It may be general fatigue, having its main effect upon the central nervous system This type is common On the other hand, it may be largely local and due to a lessening of the sensitivity of the end plate of the motor nerve in the muscle by accumulated fatigue products, or to a marked depletion of the potential energy within the muscle Rest and an efficient circulation soon restore the muscles to their normal or increased capacity

The *after effects* of exercise The changes induced by exercise in the circulatory and respiratory apparatus quickly subside The general metabolic changes in the body return to normal more slowly Exercise is beneficial when it stimulates these metabolic processes in the body and promotes functional efficiency Improved circulation, digestion, elimination and sleep should result It has been stated *There is no evidence that in a perfectly healthy man even the most intense exertion produces any harmful effect on the heart* It might be better to say on the *trained heart*

Effort syndrome—occurring during training is diminished ability to perform muscular work This phenomenon is accompanied by exaggerated respiratory and circulatory changes during exercise, and by loss of appetite poor sleep and feeling of lassitude Athletic coaches call this condition *staleness* The contractile power of the heart is lessened by overwork, resulting in a failure of the chain of events we have spoken of which supply the working muscle with an adequate supply of oxygen A similar condition also occurs following the effect on the heart musculature of the toxins of acute and chronic infectious disease and the lessened cardiac tone of sedentary life If the heart is seriously impaired, violent effort will be followed by pathological dilatation and other signs

which cannot be guarded against and the parents judgment is as good as the physician s as to whether it is worth while It teaches more things of value than perhaps any other game Basketball is one of the most strenuous of games Water polo and sprint swimming and wrestling are also very severe Crew races over two miles in length are very taxing The 440 and 880 yard runs are harder than the sprints or distance runs

The Girl —A drastic change in the physical life of girls has taken place during the last two decades From beanbags croquet Delsarte and a sporadic attempt at bicycling, they have taken up field hockey ice hockey, their own and men s basketball baseball swimming association football and track and field athletics This movement is no fad but is growing with each succeeding year In its wake come serious problems for the physician, parent and educator the proper solution of which will vitally affect the physical health of the nation

Unquestionably there are many gains to the girl from athletics Courage, self reliance sportsmanship and the ideal of teamwork' are taught The function of the heart lungs muscles and the neuromuscular coordinations are greatly improved The e activities form as with the boy, a rational outlet to superfluous energy On the other hand, certain dangers are to be feared The writer s experience and research in this phase of physical education has led to the following conclusions

Athletics when properly controlled do not tend to make the girl less womanly

When given the same care in regard to medical examination competent supervision and training she is in no more danger from heart strain than is the boy

The skeletal muscles are in no way attached to the pelvic outlet or perineum and their firm development cannot increase the difficulty of labor On the contrary the better general metabolism stronger abdominal muscles and increased physical courage developed by athletics are a distinct asset to the young woman at that time

There is no danger of organic displacement from the jumps and falls incident to athletics providing the jumping pits hurdles etc, are properly constructed and that the girl is in fine athletic condition The tone of all supporting structures is improved in direct proportion to the improvement in the tone of the skeletal muscle

During *menstruation* light exercise such as marching tactics club swinging etc should be kept up Practice in certain phases of athletics such as basketball goal shooting and signal plays form for the sprint start and similar plays may be used through the entire period More vigorous plays and even contests may be permitted after the third day with most individuals The girl should not be allowed to term this normal function illness nor in the absence of a pathological condition should she greatly modify her routine activities Carefully followed up records of gradu

up to middle life, are never overdone by the child on his own initiative, but need careful supervision in early adolescence

Exercises of *skill* such as golf, bowling, quoits, curling, etc, are applicable to any age and are especially beneficial *after* middle life

Most team sports combine several of these types and must be judged by their main elements The factors of *time* or *distance* can be used to set a reasonable limit to the indulgence in them.

The *ideal program* of physical education should include at least four elements without all of which no such program can be called complete

1 A preliminary physical and medical examination of every individual who is to participate in physical activities is essential This examination should ascertain the organic structure and functional power of the individual Girth of forearm upper arm and wrist are unimportant, but the condition of kidneys, thyroid, heart, lungs, spine and feet are vital Before exercise is resumed, a careful reexamination is essential after any illness or injury however slight

2 A carefully written prescription for special exercise should be given, to be carried out under trained supervision, whenever remediable defects are discovered

3 Regular systematic body building exercise should be insisted upon for every one Participation in athletics should be a special reason for taking this work instead of an excuse for omitting it

4 Athletics for all who are fit during at least part of the season may safely be built on this foundation There is a place at the "peak" for the varsity team composed of the physically fit, carefully trained and conditioned who may with reasonable safety be allowed to specialize in strenuous athletics

The Child—When we changed the single house with its large yard to the multifamily apartment building, we cut down the play space per child many fold Formal school gymnastics and organized play under trained supervision can but partially compensate the child for this loss The physician should back every effort to establish adequate physical training in the schools and to provide sufficient city playgrounds One well trained physical director is better than any number of unskilled instructors Competent medical examinations cannot be instituted too early in school life

The Adolescent—This is the age where strenuous athletic games are indulged in It must be remembered that rapid skeletal growth during this period outstrips that of the cardiovascular system Heavy demands are made on the youth by development, study and social activities which must be reckoned with in deciding on the proper physical education program

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2 With hands on hips
  a Heels raise lower
  b Toes raise lower
  c Heels raise knees deep bend knees straighten heels lower
3 With hands on hips
  a Trunk sideward right bend raise sideward left bend raise
  b Trunk sideward right turn sideward left turn return
  c Trunk forward lower raise backward bend raise
4 From position
  a Arms forward raise sideward carry forward carry lower
  b Arms sideward raise forward carry sideward carry lower
  c Arms forward raise upward carry forward lower downward lower
  d Arms sideward raise upward carry sideward lower downward lower
5 With hands on hips
  a Right knee raise lower
  b Left knee raise lower
  c Right knee raise extend leg forward knee bend lower
  d Left knee raise extend leg forward knee bend lower
6 To stride stand jump arms sideward raise
  a Trunk bending alternating right and left
  b Trunk turning alternating right and left
7 Hands behind head
  a Trunk bending alternately forward and backward
8 Stationary running on toes with high knee raising

Theory of Medical and Orthopedic Gymnastics

There are a number of factors relating to therapeutic exercise which have to be taken into consideration as well as the exercise itself The personal and racial inheritance of the individual his environment special stage of development, nutrition and other conditions all modify the result which we are able to attain by corrective exercises

Types of Exercise—We use for therapeutic purposes four types of exercise

1 Passive, those done wholly by the operator or by the weight of the patient s body, or other external force
2 Assistive, performed as far as possible by the patient, assisted by the operator
3 Active, the movements executed entirely by the patient
4 Resistive, done by the patient opposed by friction, gravity weights the operators or the patients' own physiologically opposing groups of muscles

It is known that as the muscle strengthens its belly becomes thicker and the entire muscle somewhat shortened thus making the distance between its origin and insertion somewhat less We are able to employ this tendency of strengthening muscle to shorten in the correction of several orthopedic defects for instance, in a faulty forward position of the

ates of normal schools of physical training have shown menstrual and maternal histories better than those of the average woman

A committee of the British Medical Association, after a thorough investigation of the subject, reported approval of field hockey, swimming dancing and track athletics (they do not play basketball to any extent) for girls Basketball under the "Women's Rules" is a much less strenuous game than that played by "Men's Rules," but the trained athlete may play either with safety Track and field athletics have reached the stage of international competition Different events are suitable to different physical types The pole vault, twelve-pound shot put and middle-distance runs are very severe and should rarely be used Distance running requires very prolonged careful training to be free from danger The special value of this sport is that, unlike other team games, everything depends upon individual effort Furthermore, it necessitates the gathering of every ounce of energy for one supreme effort Many times during life *the ability to make a quick, sure, supreme effort may result in the saving* of life or limb This ability is developed by track athletics almost exclusively Other sports teach better the lessons of team play

The physician should insist, then, upon the safeguards before mentioned, namely, preliminary and repeated medical examinations, trained supervision and proper equipment and conditions for the particular sport in question With these provisions made and organic weakness ruled out, girls should be both allowed and encouraged to take up athletics

The Adult —There is a very pressing need for games, recreational and hygienic in character that can be played with safety and pleasure in spite of increased waistline and lengthening years Golf and volley ball are perhaps the best of these games and are being increasingly used by business and professional men Tennis, when available, is good in early middle life and golf to the end of one's active career A great deal of good has been done by the recent popularizing of simple setting up drills to music and a very few minutes a day spent on individual body building exercises will bring a rich reward William Gilbert Anderson of Yale has emphasized the value of repeating several times daily such a simple procedure as straightening up fully, retracting the chin to the fullest extent and taking one or two deep inhalations A simple group of setting up exercises which should require not over six minutes to repeat four times each and which will aid materially in keeping the body in good condition are appended

Setting up Exercises

1 From "position'

a Arms to thrust raise forward thrust return lower
b Arms to thrust raise sideward thrust return lower
c Arms to thrust raise upward thrust return lower

3 Gradual lessening in the flexibility and range of motion in the joints moved by these muscles

4 A dulling of that muscle and joint sense which makes us aware of the fact that we are, or are not, in good posture

To illustrate take a case of round shoulders

a The pectorals normally somewhat stronger than the shoulder retractors may have their relative advantage increased by general fatigue or weakness

b The pectorals become more contracted by the simple fact of the forward position of the shoulder and the rhomboids the trapezius and other shoulder retractors are stretched out and weakened

c The anterior ligaments of the shoulder joint being seldom extended to their full extent tend to shorten

Fig 5—Use of Body Weight in Stretching Adhesions of Knee Joint (Courtesy Paul B Hoeber)

d The individual feels perfectly comfortable in a slumpy position and finally becomes totally unaware of it except when he may see himself in a mirror or be reminded of it by others This point is well exemplified by the ex-service man who for months after his discharge from service *catches himself slumping with decreasing frequency and finally forgets* the matter entirely except during a lecture on posture or an occasional military parade

Any exercise program for the treatment of postural defects must therefore contain at least one exercise or position aimed at modifying each one of these factors We must strengthen the weaker groups of muscles stretch those contracted maintain and increase full flexibility

head In this case development of the retractors will tend to maintain a better position of the head All posture braces, except when used as temporary expedients, such as the protection of a partially paralyzed muscle, have the opposite effect, namely, that of further weakening the muscle already below par

FIG 4—USE OF BODY WEIGHT IN STRETCHING ELBOW ADHESIONS (Courtesy Paul B Hoeber)

In practically all faulty attitudes, whether of head, shoulders, spine or feet, which are due primarily to defects in the skeleton, the following factors are present

1 Lack of balance in the power of physiologically opposing groups of muscles

2 A gradual shortening of the stronger shortened groups, with corresponding lengthening and weakening of the opponents We should visualize the muscles as strong elastic bands under partial tension When we are in fine condition, active and constantly moving our joints through their normal range this difference in elastic pull does not result in faulty posture or deformity Whenever there ensues a weakness or total paralysis of one muscle or muscle group through nerve injury, the tendency for contractures to occur in the unaffected opponents is clearly understood and usually guarded against Some means are taken to maintain and increase the tone and the strength of the weakened muscles These methods are taken up under the heading of peripheral nerve injury It is not so *well understood, however, that when there is general weakness* from whatever cause the *relative* pull of the stronger muscles is greatly increased, which gradually tends to increase the faulty posture This condition is common in chronic fatigue

general activity and special abdominal exercises Special respiratory exercises may within reasonable limits increase the lung capacity, tone up the splanchnic circulation and affect results of chronic empyema It should be recalled, however, that the normal stimulation to increase respiration is the increase in the CO_2, or hydrogen ion content of the blood, as it passes through the respiratory center in the medulla Therefore, to induce deep breathing by creating the need for more oxygen in a normal manner is better than artificial deep breathing A stationary run or vigorous gymnastic dancing steps are therefore, better than forced deep respiration

The subject of the physiology and physiological effects of general conditioning exercises for the adult and of play, gymnastics and athletics for the young unquestionably lies in the field of preventive medicine The points brought out in a study of these exercises have been dwelt upon at some length because they do not appear in medical literature to any great extent and are scattered throughout the writings on physical education in such a way as not to be easily available to the physician. The possible dangers of heart strain and other physical injuries in athletics are real, and yet the value of sports to the young is so great that a detailed study of the subject is thought worth while The family physician is being called upon for decision in regard to athletic indulgence with increasing frequency Medical and orthopedic gymnastics constitute a real and growing part of our therapeutic armamentarium The increasing interest of parents and educators in these phases of treatment requires that the physician be adequately informed regarding them

and reeducate the muscle sense, while attempting to increase the general body tone

e Lastly we must see to it that the child is built up in his general physique through general, bilateral exercises, play and improved hygiene

Before treatment for any given postural defect is instituted, the causes for such defect must be carefully studied and, where possible, removed The special treatment for these conditions, such as affecting head, shoulder, spine and feet, are taken up in detail in their special sections It will be found that the causes for most of these conditions are in general quite similar and fall into two main groups, which we might term the *strain* and the *resistance*

In the former group we have defects of hearing, vision, improperly constructed school seats and the habitual unilateral methods of carrying burdens, especially by children, the construction of ill fitting and improperly applied clothing Clothing supports and abnormal attitudes assumed to relieve pain have also to be considered

The factors, on the other side, which lower the resistance of the body to the strains put upon it include malnutrition, too rapid growth, the effects of toxins of acute and chronic disease, and the lack of normal healthy play and exercise

It is evident that if the strain is great enough even the relatively normal child may be deformed, while the child below par physically may be affected by comparatively slight habitual strains

The causes found in the first group mentioned should be removed or lessened, as far as possible, in every case of postural defect Attention should be carefully directed toward any of those etiological conditions found in the second group which can be removed

It would obviously be futile to prescribe a set of severe corrective exercises for a child so undernourished that he is unable to carry the regime of study and work already imposed upon him His burden should be lightened, his diet made ample, until he has sufficient physical foundation for special work He should, figuratively speaking, be turned out into the pasture In fact, many defects rapidly disappear when these general fundamental indications are taken care of

Medical gymnastics aim to improve the function of various organs of the body both directly and indirectly The heart, being itself a muscle, may be carefully and progressively trained to improved function, except in those cases where organic lesions have progressed too far Functioning of the nervous system may be markedly affected by reeducating the neuromuscular coordination In fact, with subnormal children, a marked toning up of even the higher mental processes has followed systematic and thorough training of this type The activity of the gastro intestinal tract and the glands which supply it may be favorably affected, both through

general activity and special abdominal exercises Special respiratory exercises may, within reasonable limits, increase the lung capacity, tone up the splanchnic circulation and affect results of chronic empyema It should be recalled, however, that the normal stimulation to increase respiration is the increase in the CO_2, or hydrogen ion content of the blood, as it passes through the respiratory center in the medulla Therefore to induce deep breathing by creating the need for more oxygen in a normal manner is better than artificial deep breathing A stationary run or vigorous gymnastic dancing steps are, therefore better than forced deep respiration

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CHAPTER VI

MECHANOTHERAPY

WILLIAM A. HEALEY

Historical and Introductory.—Of all therapeutic means used by man up to the present time the application of exercise for the restoration of bodily function most nearly approaches nature's own method of maintaining function.

Just when exercise was first utilized in a therapeutic way is not known certainly. The earliest writings of the Chinese and Hindus indicate that these people advocated the use of exercise in a hygienic way. The Greeks, at the prime of their civilization, employed the bath and exercises and wrote of these methods as a means to maintain bodily function. Through the Greeks the Romans learned of, and improved upon, the methods. Through the middle ages little advance in this subject was made, and, in fact, it was not until the seventeenth and eighteenth centuries that scientific thought was turned to exercise, and further advancement made.

Friedrich Hoffman, a German, 1780, and later Peter Henric Ling, 1786-1839, a Swedish gymnast, developed this subject and formulated specific free movements, upon which all modern systems of free exercise are still based. Ling's work definitely connected exercise with massage, which manipulations he classed as "passive gymnastics." He started in life as a fencing teacher and was attracted by the benefits derived from exercise in developing the Central Institute of Gymnastics in Stockholm. From his writings and those of others, it would seem that he appreciated the application of exercise but lacked the scientific knowledge of its indications or contraindications. His work, however, with that of Metzger, a physician in Holland, attracted the attention of many of the well known physicians of that time, and it was following the influence of these two men and the investigation by scientific medical men, that medical gymnastics found a place in the curriculum of the physicians.

About the middle of the last century, Gustave Zander devised some ingenious apparatus to localize exercise to a given part and to eliminate, to a large extent, the gymnast who, according to the Ling system, was so important. These machines were so constructed that both active and passive movement was possible.

To-day, mechanotherapy is utilized as a department of physical therapeutics and used in conjunction with the other physiotherapeutic means for the restoration of function. Its aim is to exercise systematically those organs forming the motor apparatus, thereby primarily improving or restoring their function, and secondarily improving the function of the other organs of the body.

The necessity of treating this subject in conjunction with other physiotherapeutic means has been appreciated by those who did so much scientifically to advance exercise as a means of treatment. During the period of development of this form of treatment massage was usually used in conjunction with exercise, and during the recent War large departments were formed in the army hospitals of those nations engaged in the war combining not only exercise and massage, but also all the other known physical means for the improvement or restoration of function, such as baths, heat in its various forms, and electricity. At the present time many institutions have all of these departments correlated under a physical therapeutic director. This development has been quite rational, for it is easy to see that the enlarged or diseased portion of the body will tolerate active exercise better if preceded by massage, and in turn will tolerate massage better if preceded by one of the various forms of heat. It seems logical that the future development of mechanotherapy lies in its being further developed as a department of physical therapeutics.

In judging the effect of exercise one should understand the purposes for which exercise is usually prescribed. These are threefold:

1. For educational purposes.
2. For direct restoration or the improvement of function of a diseased or injured member of the motor apparatus.
3. For the secondary or indirect improvement of function of those organs not units of the motor apparatus per se.

It is through the combination of rest and exercise that the body is maintained in a state of health. Excess of either of these is not beneficial. Educational exercise given to school children either in the form of gymnastics or sports has shown its value in increasing growth, general development and endurance sufficiently well to require no lengthy explanation at this time. All the armies of the world have kept their soldiers in a state of physical fitness through the routine application of exercise.

THERAPEUTIC EFFECTS OF EXERCISE

We are here chiefly concerned, however, in the effect of exercise from a therapeutic standpoint, and will consider the effect of exercise from this standpoint. The units forming the motor apparatus of the body are made

up chiefly of bone, joints, muscles and their nerve supply It is well known that the ordinary physiological exercise performed in daily work conduces to physiological hypertrophy of muscle, thus the occupational development of the blacksmith or iron worker may be seen in contrast to the underdevelopment of the sedentary worker It is not only that muscle hypertrophy is seen following exercise, the development of the bony structures follows directly in children at the age of one year, when most children begin to walk The bones are soft and lack, at least from a radiographic point of view, the strength and internal structure seen in children who have walked for even a few months This has been clearly expressed by Wolf, whose word is law on the development of bone, and who states that change in the formation and function of bones, or of their function alone, is followed by certain definite changes in their internal architecture, and equally definite secondary alterations of their external conformation in accordance with mathematical laws" Conversely, patients who have been bedridden for some time, lacking normal exercise, are seen to show a wasting and lack of tone in their muscles, and splinting of one of the extremities for even a week or two will produce definite atrophy of the part This is further confirmed by radiographic examination where, after prolonged rest, the bones of the immobilized part will show the well known atrophy of disuse These changes are in all probability due, in turn, to the effect of exercise on the circulatory system When a muscle contracts, the venous blood is mechanically pressed out of the veins in and around the muscles As the muscle relaxes, more venous blood is sucked into the recently compressed vessel This hastens the speed with which the blood normally passes to the part, thereby placing a demand for more blood to the part, with a resultant dilatation of the arterioles in the part Coincident with this, the lymph channels hasten their flow

Of secondary importance are the fascial coverings of the muscles which upon contraction and relaxation of the muscles act as a sort of compressor to the muscle as a whole aiding in the compression and relaxation of the vessels within This may be seen in the neck where, in hyperextension, the fascial sheaths compress the large external jugular veins, *depleting them of blood* By skillfully applied exercise one may actually deplete one portion of the body of blood, as is so commonly seen where hyperemia in the head resulting in congestive headache, is relieved by a rapid short walk It must be remembered that with alteration in the length of muscle and fascia, which increases with active or passive exercise, there is a coincident change in shape in the blood vessels of the part, so that in relaxation the vessel is longer and narrower, while in contraction the vessel is shorter and wider This change in shape assists in increasing the rapidity of the flow of blood through the part When these local changes occur in the larger vessels of the body, such as the femoral

or axillary, there is a definite demand placed upon the heart for increased activity. The response is an immediate increase in the heart's rate due to the increase of blood thrown into the right auricle. As the heart rids itself of this blood by increasing its rate and force, there is an initial dilatation of the larger arteries to receive it, which, as the exercise is increased and the blood is more evenly distributed, causes a diminution in the size of the artery, thereby increasing the blood pressure.

The products of oxidation produced by muscle activity stimulate the respiratory system to further work. The call of the body for further oxygen has not shown itself in the increased activity of the respiratory organs. With most general exercise the muscles of the chest are brought into function and this is further increased in the demand of the body for further oxygenation, and furthermore acts mechanically upon the heart. This call for increased oxygenation in even moderate exercise results in a filling of the lungs which under normal breathing fail to fill completely, decreasing the amount of residual air and in turn developing the lung power. The close relation between the cardiac and pulmonary systems under exercise cannot be underestimated when one visualizes not only their mechanical proximity but the marked influence of the pulmonary circulation upon both the cardiac and respiratory systems.

Effect of Exercise on Digestion.—One of the most important factors in the effect of exercise upon the digestive system is the action of the diaphragm. Forceful contraction of this muscle, increasing intra-abdominal pressure, increases the rapidity of flow in the great splanchnic vessels and also exerts some pressure upon the vena cava as it passes through it. Increased activity of the diaphragm and of the abdominal muscles improves the peristaltic action, also, according to some authors, acting as a sort of liver and gall bladder massage. The increased peristaltic action places greater demand upon the intestinal secretory glands, improving the absorption and assimilation of the food, which in turn results in an improved nutrition of the body in general.

The striking effect of exercise is seen among those who do active outdoor work. It is not uncommon for such people to have a daily intake of from 4,000 to 5,000 calories, while those of sedentary occupations rarely ingest more than 2,000 to 2,500 calories per day.

Effect of Exercise on Nervous System.—One of the most important effects of exercise is seen upon the brain and nervous system. This is particularly true of special exercises given for therapeutic purposes. Precision in movement requires an alert mental effort and rapt attention to the work at hand. In exercises directed locally the patient is required to differentiate between the workings of the individual muscle groups supplied by various innervations, giving him an acute appreciation of control of the various muscle groups. This is of particular value in cases of partial paralyses where the improvement of the remaining muscles of

up chiefly of bone, joints, muscles and their nerve supply It is well known that the ordinary physiological exercise performed in daily work conduces to physiological hypertrophy of muscle, thus the occupational development of the blacksmith or iron worker may be seen in contrast to the underdevelopment of the sedentary worker It is not only that muscle hypertrophy is seen following exercise, the development of the bony structures follows directly in children at the age of one year, when most children begin to walk The bones are soft and lack, at least from a radiographic point of view, the strength and internal structure seen in children who have walked for even a few months This has been clearly expressed by Wolf, whose word is law on the development of bone, and who states that change in the formation and function of bones, or of their function alone, is followed by certain definite changes in their internal architecture, and equally definite secondary alterations of their external conformation in accordance with mathematical laws" Conversely, patients who have been bedridden for some time, lacking normal exercise, are seen to show a wasting and lack of tone in their muscles, and splinting of one of the extremities for even a week or two will produce definite atrophy of the part This is further confirmed by radiographic examination where, after prolonged rest, the bones of the immobilized part will show the well known atrophy of disuse These changes are in all probability due, in turn, to the effect of exercise on the circulatory system When a muscle contracts, the venous blood is mechanically pressed out of the veins in and around the muscles As the muscle relaxes, more venous blood is sucked into the recently compressed vessel This hastens the speed with which the blood normally passes to the part, thereby placing a demand for more blood to the part, with a resultant dilatation of the arterioles in the part Coincident with this, the lymph channels hasten their flow

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Physiology of Muscles—Before considering this very important aspect of muscles, let us review briefly the histological structure of muscle, upon which its physiology depends The essential unit of the muscle is the fiber—a minute highly specialized body cell, appearing as a minute thread varying from 01 mm to 1 mm in diameter, and from 5 to 15 cm in length This is made up in turn of a sarcolemmal sheath within which is contained the sarcous substance or muscle plasma The sarcolemma is a structureless, elastic membrane and it alone comes in contact with the connective tissue by which the muscle fibers are attached one to another The muscle plasma is made up of long threadlike fibrils which, being of alternate light and dark bands, give a characteristic cross striation to the muscle and which are the essential contractile portion of the muscle The viscous material between the fibrils, known as the sarcoplasm, is supposedly the nutritive element in the muscle fiber Muscle fibers are banded together by delicate connective tissue which groups them into primary bundles this connective tissue portion being known as the endomysium The sheath surrounding the primary bundles is the perimysium These primary bundles are again grouped into secondary bundles and enveloped in a sheath known as the epimysium each secondary bundle being known as a separate muscle fasciculus

The physiological properties of striated muscle are

1 *Contractility*—By this we mean its ability to shorten itself in response to a stimulus by which it is able to perform its work The normal stimulus is usually the nerve impulse, voluntary in the striated muscles and acting reflexly in the unstriated muscles While this property of contractility is present in all muscular tissue, it is not confined to muscular tissue being also a property of the ciliated epithelial cells of the mammalian body Through this contractile power muscles shorten themselves in varying degrees this variation being from 10 per cent to 50 per cent of their normal lengths during physiological exercise

2 *Extensibility*—By extensibility we indicate the power of muscle to permit of lengthening without tearing Most muscles are stretched between their points of origin and insertion We know that if a tendon is cut even with the muscle relaxed the fleshy part of the muscle draws the tendon toward its origin This slight stretching under which the muscles are normally maintained assists very much in the smooth working of the motor apparatus This power of extensibility, when studied in comparison with the extensibility of dead elastic bodies is found to differ markedly from them While the extensibility of an elastic band is proportionate to equal increments of weight the extensibility of muscle shows a proportionate decrease with each equal increment of weight It has been found that the decrease in the power of extensibility to increments of weight holds true up to the point where a muscle reaches

the same group would, to some degree, compensate for the loss of an individual muscle

Frankel has correlated a complete system of exercises which have accomplished much in re training those suffering from locomotor ataxia, utilizing the other sense perceptions for the loss of muscle sense perception The effect of exercises on purely functional neurological conditions is not to be disregarded By means of properly applied exercise, either a sedative or stimulating effect may be obtained Many of the purely functional neurological conditions have recently been explained upon the basis of an endocrinasthenia, and it is possible that the effect of exercise in these cases is accomplished by the physiologically improved function of the organs of internal secretion through increased blood supply and nutrition

Effect of Exercise on Genito urinary System—The most important physiological effect of exercise on the genito urinary system is the temporary relief of passive congestion when present in the kidney The changes above noted in the circulatory system, the distribution of blood to other parts of the body, the diaphoresis occurring with exercise, all relieve the kidney of work which it would ordinarily be called upon to do However, this is a rather transient accomplishment, and does not warrant the prescription of exercise for dysfunction of the kidney, as in carefully selected cases The reflex depletion of the blood to the entire genital apparatus is of more importance, thereby lessening local irritability

Effect of Exercise on Metabolism—No other therapeutic agent has so definite an effect upon metabolism is exercise Howell has tabulated the mechanisms of heat production and heat dissipation as follows

Heat production
Chemical regulation
  1 Motor nerve centers and motor fibers to the muscles
  2 Stimulating action of food on metabolism
Heat loss
Physical regulation
  1 Sweat centers and sweat nerves
  2 Vasomotor centers and vasomotor nerve
  3 Respiratory center

In this we see the important metabolic process of heat regulation definitely acted upon by exercise Heat loss through the sweat centers, vasomotor centers and respiratory center, is definitely accelerated exercise, while, on the other hand, heat production, although of chemical regulation, is likewise accelerated by exercise The acceleration of the metabolic processes has, coincident with it, an acceleration of the digestive functions, permitting more rapid assimilation This not only permits a greater intake of food, but its more rapid absorption, thereby improving the general body economy

leg, the hamstring muscles are shortened and are active concentrically If, however, the same patient with knee flexed attempts to hold the knee in this position and is overcome by the force utilized by the masseur or machine, the flexor muscles are still working but actually being lengthened while working and hence are said to work eccentrically

Active motion is also divided into three phases of muscle action

1 Positive phase in which a muscle contracts

2 Static phase during which the muscle is maintained in a state of complete or incomplete contraction

3 Negative phase during which muscle ends are gradually being separated

To illustrate—during dorsi flexion of the wrist the extensor carpi ulnaris and radialis perform a positive action If the wrist is now maintained in dorsi flexion without further movement a static action of these muscles is seen As the wrist is then lowered complete relaxation of these muscles does not occur immediately but they are gradually lengthened as the wrist is brought down This is the negative activity of a muscle

One of the most important factors in proper application of exercise is the localization of the treatment to the joints and muscles to be exercised If we take, for example, a foot condition wherein adduction exercises are indicated, and during exercise permit the patient to plantar flex the foot alone, instead of adducting we are defeating the purpose for which the exercise was prescribed

According to Schwann's law of the physiological action of muscle we know that the strength of a muscle is in direct proportion to its state of contraction This is of importance in graduating the dosage of resistance in giving resistive movements for, at the beginning of contraction and at the end the strength of the muscle is lessened so that the resistance should be strongest in the middle third of the movement Again in the treatment of a regenerating musculo spiral nerve, when the extensors of the wrist and fingers are beginning to show return of function if we instruct the patient to move the wrist in extension as much as possible instead of ordering a few brief, well directed extensor movements to his wrist he will in his efforts to extend the wrist activate his flexor groups as soon as the extensor muscles are fatigued thereby actually causing the exercise to be detrimental to his recovery The progression of exercise should be gradual and may be accomplished by increasing speed duration or resistance applied in the exercise

General Exercises—We know it is general bodily activity that maintains the harmonious coordination of the various systems of the body It is reasonable, therefore, to suppose that in the application of exercises in a therapeutic way, active free exercise offers most improvement

its normal physiological limit of extension If equal weights are added after this point the muscle follows the law of dead elastic bodies and *extends in equal proportions to each added increment of weight* Extensibility remains a property of muscle even after rigor mortis

3 *Elasticity*—When a muscle has been extended within its physiological range of extensibility and the extending force is removed, it *regains its normal state through its power of elasticity* This property is found only in living muscle, and although it is not as great as the elasticity found in some dead elastic bodies, its elastic power is none the less perfect The slightly stretched condition of muscle between *its origin and insertion probably tends to maintain the tone of the* muscle, thereby making more smooth the elastic recoil

4 *Irritability*—Muscle irritability is the functional activity of a muscle in response to a stimulus The normal nerve stimulus was first *eliminated by Claude Bernard, who, by injecting curare, paralyzed* the motor nerve endings Direct stimulation of the curarized muscle, either electrically or mechanically, initiates functional activity within the muscle, demonstrating an independent muscle irritability

It is through these four properties that muscles perform their normal work and through the improvement of these properties that exercise *restores function to the muscle*

CLASSIFICATION OF GYMNASTIC MOVEMENTS

Ling classified all movements as follows

1 *Passive movements* or those wherein no active innervation is performed by the individual the motor power being supplied by another person or by suitable live apparatus

2 *Active movements* or those wherein the individual innervates his own *muscles and performs work through the movements of his muscles* Active movements are again subdivided into

a. Free movements those performed by the individual without external *help*

b Controlled movements by which is meant those exercises limited or supported by various apparatus

c Resistance movements during which the active movements performed by the patient are resisted by the gymnast or by apparatus

Resistance movements are said to be either concentric or eccentric. Concentric movements are those in which the muscle, while working against resistance, shortens its total length while eccentric movements *are those during which the muscle while working is gradually length*ened by the external force applied This may be illustrated by resistant movement, when a patient flexes his knee with the resistance of the *masseur's hand or machine directed against the back of the patient's*

contractions in capsules, ligaments or synovial membranes may be definitely improved by gradual, slow, even movements given over long periods of time Passive exercises are rarely indicated in the lower

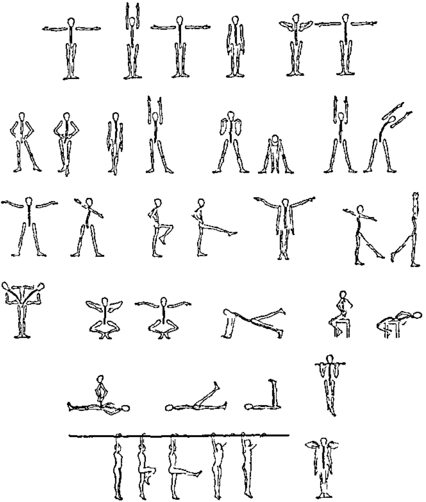

Fig 9 —A Few Derived Movements from the Fundamental Positions

extremity for what cannot be accomplished by ordinary walking will surely not be accomplished through the application of passively applied movement

Mechanical Aids —Many kinds of apparatus have been devised to exercise a part or the whole of the body Among these the best known

in bodily function, and it is only in those cases wherein active free exercises cannot be accomplished that the passive form of exercise or the use of mechanical means are indicated Many so-called systems of active exercises have been developed but none have superseded the original Swedish system originated by Ling and his followers This school had, as its basis, five fundamental positions, namely, standing, sitting, kneeling, lying and hanging From these positions the derived positions were taken For instance, from the standing position arm, leg and trunk exercises are given Likewise, from the sitting position the arm, leg and trunk exercises may be given, and so on, utilizing the fundamental positions as a starting point and building the individual exercises or derived positions from these fundamental positions It is readily seen that countless numbers of combinations of exercises may be worked out

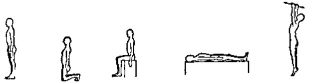

FIG 1—FUNDAMENTAL POSITIONS FROM WHICH EXERCISES MAY BE DERIVED In outlining a table of exercises for a given condition the standing or lying position is first utilized from which derived movements are made dependent upon the fatigability of the patient As improvement is gained the period of exercise is lengthened gradually manual resistance may be offered and still later other fundamental positions utilized until eventually the patient is able to tolerate all of the various fundamental positions with their derived exercises In the local treatment of a part by exercise resistance movements are of greatest value in improving local function

from these fundamental positions The accompanying sketches illustrate the five fundamental and a few of the derived positions from the various fundamental positions (Figs 1 and 2)

Passive Movements—Passive movements have heretofore been credited with far greater range of applicability than they are to-day Those who are constantly using exercises in a therapeutic way appreciate that, aside from the relatively limited number of cases wherein actual joint stretching is required, or where the slight local circulatory improvement resulting from passive motion is indicated, passive exercises have little therapeutic value It is readily seen that where a muscle fails to receive its own nerve supply its irritability and contractility are not stimulated to activity It is true that the elasticity and extensibility of the muscle are called into play but the injury sustained by the contractile fibers would hardly be compensated for by the improvement gained in the elastic or extensible structures However, passive movements have an important role to play in the treatment of chronic joint affections, where

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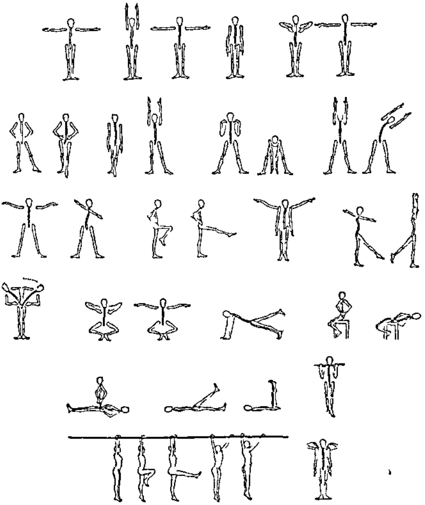

FIG —A FEW DERIVED MOVEMENTS FROM THE FUNDAMENTAL POSITIONS.

extremity, for what cannot be accomplished by ordinary walking will surely not be accomplished through the application of passively applied movement

Mechanical Aids—Many kinds of apparatus have been devised to exercise a part or the whole of the body Among these, the best known

are the Zander, based on the principle of the lever with movable weight, the Krukenberg pendulum apparatus, and the Herz modification of the Zander apparatus If we disregard the passive movement machines, whose sphere of action is very limited, we find that the importance of the machines lies in the resistance to efforts against a muscle, and the localization of exercise to definite muscle groups This resistance may be afforded by the weight and lever Zander, by friction against a brake in the turning of a wheel, or by stretching or compressing springs The principle of raising a weight by means of a lever has more recently been modified to raising weights by rope and pulley

Scholz, in his *Manual of Mechanotherapy* states that "apparatus for medical gymnastic exercises should meet with these requirements

"1 It must be constructed in such a way that the patient in the apparatus is in the correct, original position, that is, the apparatus must prevent any indirect, secondary contractures of muscles This is obtained by arrangement for support and fixation

"2 The apparatus must allow the intended position properly to be done from an anatomical, as well as from a medical gymnastic point of view

3 It must allow exact dosage and control of quantity of exercise

"4 Apparatus for resistive movements must allow exact dosage and regulation of the exercise which is to be given"

Following Ling's development of a rational system of free exercise, Zander constructed apparatus by which exercise might be given without the assistance of a trained gymnast He constructed in all some thirty six machines for active movements, including those for the upper and lower extremity and trunk. He then devised motor-driven apparatus for balance movement, passive movement, vibration, percussion and kneading and friction Along with these, machines for the correction of scolioses and various measuring apparatus completed his contribution to mechanotherapy The machines for active exercise were constructed on the principle of the weighted lever, by which certain muscle groups were activated by the movement of the lever The degree of resistance was graduated by moving the weight upon the lever Motor-driven passive exercise machines were constructed upon the same principle, and were of definite value in that the smoothness, continuity and uniformity of the movement was superior to that applied by a gymnast

The advantages of the Zander apparatus lie in the graduation of the force and resistance, the human factor of the gymnast being eliminated However, the proper application of the machines requires the attendance of one trained in therapeutics of exercises to gage the amount of resistance required and to sense the expressions of fatigue when the

exercises are applied. In addition to this the machines are expensive, rather cumbersome to operate, requiring motor force, much space and shafting, and the constant care of a mechanic to keep them in working order. Where these are not objections the Zander apparatus may be used with decided benefit.

Under the stimulus of the war, E. A. Bott, of Toronto, and R. Tait McKenzie, of Philadelphia, developed simpler apparatus based on the raising of weights by rope and pulley principle and of extreme simplicity in construction. The general principle of raising weights as in the Zander apparatus is maintained and the objectionable factors, namely, the cumbersomeness, difficulty of operation, space and technical knowledge required in the Zander apparatus are eliminated. These machines are constructed so as to exercise one movement in a joint and are all active motion machines save those for circumduction in the wrist and ankle. These are so-called active-passive machines, that is, the movement is started, as in the Krukenberg pendulum apparatus, by revolving a wheel to start the exercise, and the wheel is kept moving by the activity of the patient's own muscles. Many of the machines are fitted with scales, particularly those for the hands and feet, whereby a patient may actually see the graded improvement, and this acts as a stimulus to further effort. The triplicate-pulley weight machine shown in Figure 3 shows the simplicity whereby resistance may be arranged upward, downward or from the side. The range or resistance is graduated by the addition or elimination of weight.

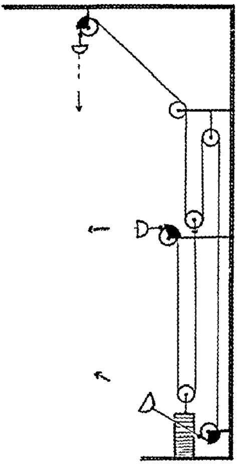

Fig. 3.—Triplicate Pulley Weight Machine By Which Resistance May Be Offered Upward, Downward or in the Horizontal Direction.

are the Zander, based on the principle of the lever with movable weight, the Krukenberg pendulum apparatus, and the Herz modification of the Zander apparatus If we disregard the passive movement machines, whose sphere of action is very limited, we find that the importance of the machines lies in the resistance to efforts against a muscle, and the localization of exercise to definite muscle groups This resistance may be afforded by the weight and lever Zander, by friction against a brake in the turning of a wheel, or by stretching or compressing springs The principle of raising a weight by means of a lever has more recently been modified to raising weights by rope and pulley

Scholz, in his *Manual of Mechanotherapy* states that "apparatus for medical gymnastic exercises should meet with these requirements

"1 It must be constructed in such a way that the patient in the apparatus is in the correct, original position, that is, the apparatus must prevent any indirect, secondary contractures of muscles This is obtained by arrangement for support and fixation

"2 The apparatus must allow the intended position properly to be done from an anatomical, as well as from a medical gymnastic point of view

"3 It must allow exact dosage and control of quantity of exercise

"4 Apparatus for resistive movements must allow exact dosage and regulation of the exercise which is to be given"

Following Ling's development of a rational system of free exercise, Zander constructed apparatus by which exercise might be given without the assistance of a trained gymnast He constructed in all some thirty six machines for active movements, including those for the upper and lower extremity and trunk He then devised motor driven apparatus for balance movement, passive movement, vibration, percussion and kneading and friction Along with these, machines for the correction of scolioses and various measuring apparatus completed his contribution to mechanotherapy The machines for active exercise were constructed on the principle of the weighted lever, by which certain muscle groups were activated by the movement of the lever The degree of resistance was graduated by moving the weight upon the lever Motor-driven passive exercise machines were constructed upon the same principle, and were of definite value in that the smoothness, continuity and uniformity of the movement was superior to that applied by a gymnast

The advantages of the Zander apparatus lie in the graduation of the force and resistance, the human factor of the gymnast being eliminated However, the proper application of the machines requires the attendance of one trained in therapeutics of exercises to gage the amount of resistance required and to sense the expressions of fatigue when the

Exercise 2—Horizontal attachment Flex interphalangeal joints keeping metacarpophalangeal joints extended

Exercise 3—Low attachment Extend metacarpophalangeal joints, keeping metacarpophalangeal joints extended

Exercise 4—Low attachment Extend metacarpophalangeal and flex interphalangeal joints

The operator seated opposite the patient should count the repetitions and encourage his efforts Each exercise to be continued till movement shows flagging and then stopped The most convenient weights are shot bags loaded to two ounces each and attached by hooks They can easily be made and repaired by the masseur

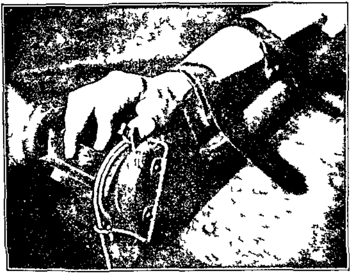

Fig —Finger Treadmill.

3 **Thumb Adduction and Abduction**—Hand in pronation Attach the stool on the radial side to the thumb for adduction

Exercise 1—Draw the thumb across the hand Repeat the movement to the point of exhaustion

Exercise 2—Attach the stool on the ulnar side of the thumb draw thumb out in abduction Repeat to exhaustion

4 **Finger Treadmill** (Fig)—For voluntary flexion of fingers Strap the wrist and turn the wheel by flexing the fingers in turn till exhaustion of each finger The amount of work done by a single finger can be calculated by using that finger only, and noting the weight and distance it is raised

5 **Circumduction of Wrist for Stretching** (Fig) —Strap the wrist and forearm grasp the handle and turn the wheel about twenty revo-

McKenzie gives the following instructions for the use of the various types of apparatus

Upper Extremity

1 **Finger Board**—(*a*) For stretching contractions of the fingers, in flexion, and (*b*) for stretching abduction at the metacarpophalangeal joints

Extension of Single Fingers—(*a*) The fingers are placed on the board in moderate flexion, and the finger under treatment goes up the stair, step

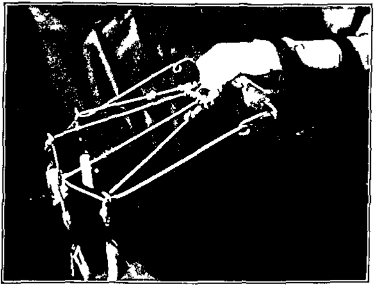

Fig 4—Finger Pulleys

by step Note the last step at which the finger under treatment can be raised from the step without assistance Depress the hand to stretch still farther

(*b*) Place the index finger against the peg at 1, and spread the second finger out, noting the farthest point at which it can touch the peg Repeat with the second, third, and fourth fingers Repeat each movement not more than five times

2 **Finger Pulleys** (Fig 4)—*For flexion and extension of the fingers*, strap the wrist and arm at the elbow, insert the fingers into the glove stools and add weight until it can barely be lifted by the voluntary power of each finger The weights are increased as improvement goes on, and the movements repeated up to the point of exhaustion

Exercise 1—High attachment Flex metacarpophalangeal joints keeping interphalangeal rigidly extended

Exercise 2—Horizontal attachment Flex interphalangeal joints keeping metacarpophalangeal joints extended

Exercise 3—Low attachment Extend metacarpophalangeal joints keeping metacarpophalangeal joints extended

Exercise 4—Low attachment Extend metacarpophalangeal and flex interphalangeal joints

The operator seated opposite the patient should count the repetitions and encourage his efforts Each exercise to be continued till movement shows flagging and then stopped The most convenient weights are shot bags loaded to two ounces each and attached by hooks They can easily be made and repaired by the masseur

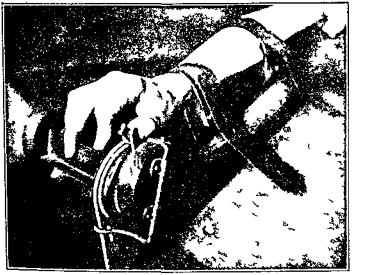

FIG —FINGER TREADMILL.

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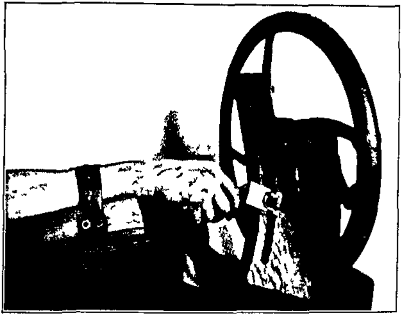


FIG 6 —CIRCUMDUCTION AT THE WRIST Apparatus may be used actively and passively

lutions each way Move out the attachment to the farthest possible point compatible with the movement The operator may assist at the most difficult part of the turn by turning the crank

FIG 7 —ABDUCTION AND ADDUCTION OF WRIST Note scale showing range of motion and small handle to brake machine to increase resistance

6 **Adduction and Abduction of Wrist** (Fig 7) —Place the fingers under the straps on the hand board, strap down the wrist and forearm,

adduct and abduct the hand noting the range of movement on the protractor The weights will vary for these two movements, which should be done separately

7 **Flexion and Extension of Wrist**—(*a*) Grasp the roller overhand and wind up the weight, exerting the full range of movement without releasing the grasp The scale will measure the range of the joint and the weight and distance multiplied gives the total work done in foot pounds (*b*) Reverse the grasp and repeat for flexion

8 **Pronation and Supination** (Fig 8)—Patient stands facing machine and grasps the handle with the left hand, his left elbow joint flexed

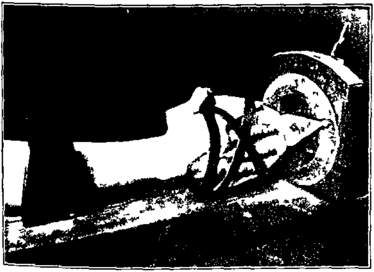


Fig 8—Pronation and Supination of Wrist

his right forearm across his back, and his hand grasping his left arm above the elbow to prevent sideways movement. Set weight and ratchet for supination and turn, counting the clicks for each movement and noting the weight and the distance raised The measurement of each movement will appear on the protractor Reverse the ratchet and repeat for pronation.

9 **Flexion and Extension at Elbow**—(*a*) The patient faces the triplicate machine grasping the floor handle the arm and cord in line Flex and relax the forearm (*b*) Patient faces away from the machine grasping the shoulder handle the arm full flexed the upper arm in line with the cord Extend and relax the forearm In both these exercises the position of the upper arm must remain unchanged If this is not done, the direction of the pull is changed

10 **Shoulder Rotation**—Grasp the floor handle the elbow on a bracket, shoulder high, the forearm flexed to a right angle Pull up with the hand, throughout whole range of shoulder movement without changing the height of the elbow or its angle of flexion

11 **Flexion and Extension of Shoulder Joint**—(*a*) The patient stands with his back to the floor handle, the arm down and straight Arm forward, raise and lower (*b*) Face to the floor handle, draw the arm back, and lower to position

12 **Adduction and Abduction of the Shoulder**—The patient stands with the side to the triplicate machine shoulder attachment, arm and cord in line (*a*) Bring the arm forward across the chest (*b*) Patient stands

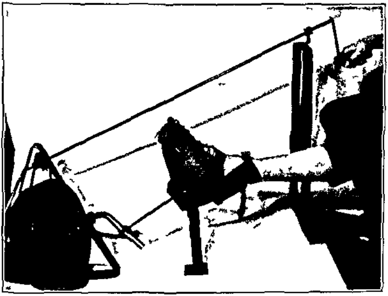


FIG 9—CIRCUMDUCTION OF ANKLE

as in Exercise 1 but using the floor attachment Bring the straight arm upward and lower to position (*c*) Patient stands with his side to the machine overhead attachment, arm in line with the cord Bring the arm downward and forward then downward and backward, alternately (*d*) Patient stands with the side from the machine, the arm across chest, grasping the shoulder attachment Extend the forearm and arm, keeping them at the shoulder level

13 **Passive Abduction of Shoulder**—Patient standing with the side to the creeping board, and the forearm rigidly extended Climb up the board by the fingers with a straight arm, and note (*a*) the highest point at which the fingers can be lifted from the board by the patient (*b*) the level to which the patient can bring up his arm without bending his elbow

General movements that are of value in treating the muscles of the upper extremity are rolling up a ball of paper, throwing and catching balls of all sizes and weights, quoits, bowling, ping pong, crokinole, billiards, weaving, knitting, rope splicing, making knots, the use of tools such as scissors, boring, hammering, modeling, painting, bookbinding, saddlery, and shoemaking.

Lower Extremity

1 Circumduction of the Ankle (Fig.) —The patient sits with his foot strapped in place. The range of movement is regulated by a thumb screw on the crank. The handle is turned by the patient or operator for this stretching movement, which should precede the voluntary active movements of the ankle.

2 Inversion and Eversion of Foot (Fig 10) —(*a*) The patient walks on the inversion ridge a definite distance with hand rail support. (*b*) ditto for eversion.

3 Dorsiflexion of Ankle — The patient sits or stands with his foot strapped to the footpiece. Flex the ankle, raising the weight. The extent of the movement may be estimated by the number of clicks, the exact measurement noted on the protractor, and the total work done is easily calculated.

Fig 10 —Inversion and Eversion Boards.

4 Rotation of the Knee —(*a*) Patient is seated with the foot strapped to the footpiece and the leg against the brace. He adducts or abducts the foot, rotating the knee, the extent of each movement being marked on the protractor. (*b*) The patient stands with the knee locked in extension and adducts or abducts the foot. This movement measures hip rotation if care is taken to keep the pelvis fixed. In either position the movement of the flexed ankle is slight.

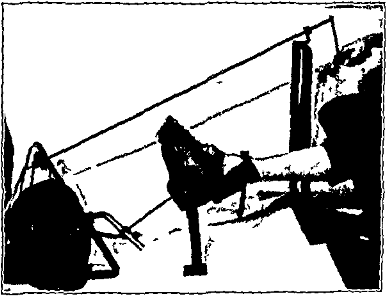
5 Knee Flexion and Extension (Fig) —Triplicate machine.

Exercise 1 Face to the machine, strap the foot to the floor attachment. Movement: Flex the knee against resistance.

10 Shoulder Rotation—Grasp the floor handle the elbow on a bracket, shoulder high, the forearm flexed to a right angle Pull up with the hand, throughout whole range of shoulder movement without changing the height of the elbow or its angle of flexion

11 Flexion and Extension of Shoulder Joint—(*a*) The patient stands with his back to the floor handle the arm down and straight Arm forward, raise and lower (*b*) Face to the floor handle, draw the arm back, and lower to position

12 Adduction and Abduction of the Shoulder—The patient stands with the side to the triplicate machine, shoulder attachment, arm and cord in line (*a*) bring the arm forward across the chest (*b*) Patient stands



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Exercise 1 Side to the machine, the foot strapped to the floor attachment Movement Adduct the thigh, keeping the knee straight

Exercise 2 Side from the machine foot strapped to the floor attachment Movement Abduct the thigh, keeping the knee straight.

7 Hip flexion and extension

Exercise 1 Face to the machine, foot strapped to the floor attachment Movement Extend the thigh with the leg stretched

Exercise 2 Face from the machine foot strapped to the floor attachment. Movement Flex the thigh, keeping the knee straight

8 Thigh flexion knee flexion foot dorsiflexion—Patient steps through the rungs of a horizontal ladder with parallel bar arm rests The ladder is made adjustable for height at one end and raised to increase the movement required to raise the foot over each rung This is especially useful for leg amputation cases

9 Thigh extension knee extension foot plantar flexion The bicycle trainer with an increasing load of distance or friction (Fig (11)

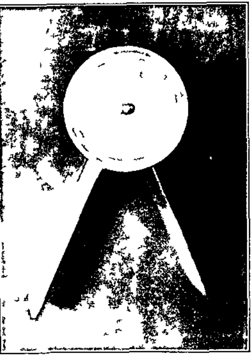

Fig 13—One Type of Protractor Scale to Measure the Range of Motion One arm remains stationary at zero the other arm free A double protractor scale facilitates the taking of measurement on the two sides of the body

Mensuration—Before starting exercise it is well to know the range of motion present at a joint so that comparison may be made after a short period of treatment to see whether or not improvement in range of motion is taking place Under too active exercise or in those cases where the muscles under active-passive exercise are strained further limitation of motion may be detected

Several simple devices have been devised consisting of jointed arms with a protractor scale one arm being fixed at zero on the scale and the other movable about the protractor indicating in degrees as it moves the arc through which it passes. This simple form is most useful in measuring the range of motion in the joints of the extremities. In some of

Exercise 2 Face from the machine, strap the foot to the floor attachment, the flexed leg and cord in the same line Movement Extend the knee against resistance

FIG 11 —STATIONARY BICYCLE. Thigh and knee extension plantar flexion of foot

6 Hip Adduction and Abduction —Triplicate machine

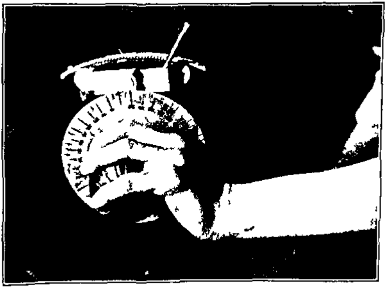

FIG 12 —GRIP MACHINE FOR IMPROVING FLEXION OF THE FINGERS AND FLEXION AND EXTENSION OF THE WRIST

which fits between the fingers. The joints are indicated with a pencil by dots on the celluloid in both full flexion and full extension. The hand is then removed from the instrument, the dots connected by straight lines and this transposed to permanent record. This is illustrated by the Rosen apparatus in Figure 14.

To appreciate the limitation in range of motion in the joint it is well to have at hand the normal mean range through which a joint moves. The following table shows the normal range usually present in joints of the extremity.

Wrist joint
  Flexion to 100 degrees. Extension to 40 degrees. Range—140 degrees.
  Abduction—zero to 15 degrees. Range—[illegible] degrees.
  Adduction—zero to 30 degrees. Range—30 degrees.
Elbow Joint
  Flexion to 45 degrees. Extension to 180 degrees. Range—135 degrees.
  Pronation—zero to 90 degrees. Range—90 degrees.
  Supination—zero to 90 degrees. Range—90 degrees.
Shoulder Joint
  Abduction—zero to 160 degrees. Range—160 degrees.
  (Note.—From zero to 80 degrees is the range in the shoulder joint itself, while from 80 to 160 degrees movement is made by elevation and rotation of the scapula.)
  Flexion—zero to 180 degrees. Range—180 degrees.
  Extension—zero to 45 degrees. Range—45 degrees.
  Internal rotation—zero to 80 degrees. Range—90 degrees.
  External rotation—zero to 45 degrees. Range—4[illegible] degrees.
Ankle Joint
  Dorsiflexion—90 degrees to 1[illegible] degrees. Range—4[illegible] degrees.
  Plantar flexion—90 degrees to [illegible]0 degrees. Range—[illegible]0 degrees.
  (Note.—Inversion and eversion of the foot cannot be measured with these simple instruments.)
Knee Joint
  Flexion to 45 degrees. Extension to 180 degrees. Range—13[illegible] degrees.
Hip Joint
  Abduction—zero to 45 degrees. Range—4[illegible] degrees.
  Adduction—zero to 4[illegible] degrees. Range—4[illegible] degrees.
  Flexion to [illegible]0 degrees. Extension to 180 degrees. Range—1[illegible]0 degrees.
  Hyperextension from 180 degrees. Extension to 13[illegible] degrees. Range—[illegible] degrees.
  External rotation—zero to 60 degrees. Range—60 degrees.
  Internal rotation—zero to 30 degrees. Range—[illegible]0 degrees.

INDICATIONS AND CONTRAINDICATIONS

Indications.—Generalized exercises are indicated in those of sedentary occupation wherein the general metabolism has fallen below its normal threshold and is evidencing itself by disturbance in one or more of the systems comprising the body. In purely systemic diseases, such as in compensated chronic endocarditis or enteroptosis, a rationally applied

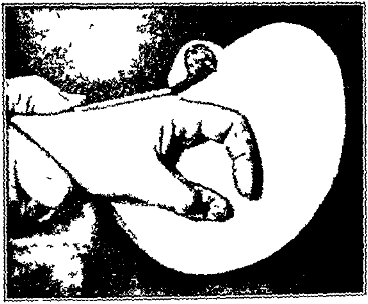

FIG. 14.—OTHER TYPE OF APPARATUS FOR INDICATING RANGE OF MOTION AT THE METACARPAL AND PHALANGEAL JOINTS

FIG. 15.—DYNAMOMETER FOR MEASURING GRIP OF HAND

the instruments the protractor scale registers from 0 to 180 while in others it registers from 0 to 360. The accompanying photograph illustrates one type of protractor, with double scale facilitating its use on the opposite sides of the body (Fig. 13)

It has been found that the measuring of finger motions with the protractor scale offers some difficulties so that a simpler form of measuring apparatus was devised to plot out the actual range of motion in the metacarpophalangeal joints. This consists of a small wooden bar which fits over the dorsum of the metacarpal bones jointed to a thin sheet of celluloid or tin

which fits between the fingers. The joints are indicated with a pencil by dots on the celluloid in both full flexion and full extension. The hand is then removed from the instrument, the dots connected by straight lines and thus transposed to permanent record. This is illustrated by the Rosen apparatus in Figure 14.

To appreciate the limitation in range of motion in the joint it is well to have at hand the normal mean range through which a joint moves. The following table shows the normal range usually present in joints of the extremity.

Wrist joint
- Flexion to 100 degrees. Extension to 240 degrees. Range—140 degrees.
- Abduction—zero to [illegible] degrees. Range—3[illegible] degrees.
- Adduction—zero to [illegible]0 degrees. Range—[illegible]0 degrees.

Elbow Joint
- Flexion to 4[illegible] degrees. Extension to 180 degrees. Range—135 degrees.
- *Pronation—zero to 90 degrees. Range—90 degrees.*
- Supination—zero to 90 degrees. Range—90 degrees.

Shoulder Joint
- Abduction—zero to 160 degrees. Range—160 degrees.
- (Note.—From zero to 80 degrees is the range in the shoulder joint itself, while from 80 to 1[illegible]0 degrees movement is made by elevation and rotation of the scapula.)
- Flexion—zero to 180 degrees. Range—180 degrees.
- Extension—zero to 4[illegible] degrees. Range—4[illegible] degrees.
- Internal rotation—zero to 80 degrees. Range—90 degrees.
- External rotation—zero to 4[illegible] degrees. Range—4[illegible] degrees.

Ankle Joint
- Dorsiflexion—90 degrees to [illegible] degrees. Range—4[illegible] degrees.
- Plantar flexion—[illegible]0 degrees to [illegible]0 degrees. Range—[illegible]0 degrees.
- (Note.—Inversion and eversion of the foot cannot be measured with these simple instruments.)

Knee Joint
- Flexion to 4[illegible] degrees. Extension to 180 degrees. Range—13[illegible] degrees.

Hip Joint
- Abduction—zero to 4[illegible] degrees. Range—4[illegible] degrees.
- Adduction—zero to 4[illegible] degrees. Range—4[illegible] degrees.
- Flexion to 60 degrees. Extension to 1[illegible]0 degrees. Range—1[illegible]0 degrees.
- Hyperextension from 180 degrees. Extension to 13[illegible] degrees. Range—4[illegible] degrees.
- External rotation—zero to 60 degrees. Range—60 degrees.
- Internal rotation—zero to 30 degrees. Range—[illegible]0 degrees.

Indications and Contraindications

Indications.—Generalized exercise is indicated in those of sedentary occupation wherein the general metabolism has fallen below its normal threshold and is evidencing it. If by disturbances in one or more of the systems comprising the body. In purely systemic disease, such as in compensated chronic endocarditis or enteroptosis, a rationally applied

general system of graduated exercises will accomplish more than any other form of therapeusis Again, in the functional neurological conditions so often grouped under the vague term of "neurasthenia," generalized exercise, by increasing the general metabolism and possibly by stimulating the organs of internal secretion, is frequently markedly beneficial

The local indications for exercise consist in the limitation of function of a part, whether it is a joint, tendon or organ In the last, as may be represented by a retracted lung in a healing empyema, the exercise of that portion of the motor apparatus, namely the chest, secondarily acts locally upon the organ within Local circulatory derangements, atrophies and contractures can frequently be prevented as well as improved when presenting, by the early institution of exercise properly applied

Contra indications—The contra indications to exercise include all those conditions in which the raising of the basal metabolism is detrimental Inflammations of all kinds, advanced depleting disease, and new growths are definite contra indications to exercise Local, healing, inflammatory disorders, by increasing the local metabolic changes, hasten, rather than retard improvement However, although this is true, care must be exercised in the election of the time when exercise will not promote an extension of the inflammatory process A short list of suitable cases follows, arranged as to the indications requiring local or general exercises

1 Requiring General Exercise
   - Constipation
   - Enteroptosis
   - Gastric or intestinal neurosis
   - Chronic passive congestion
   - Marked compensated cardiac valvular disease
   - Compensated myocarditis
   - Arterial hypertension
   - Arterial hypotension
   - Atelectasis
   - Postoperative empyemas
   - Chronic pleuritic adhesions
   - Neurasthenia
   - Hysteria

2 Requiring Local Exercise
   - Torticollis, congenital and spasmodic
   - Fractures, following reduction
   - Dislocations, following reduction
   - Amputations postoperative
   - Ankylosis, fibrous
   - Arthritis, chronic
   - Contractures, cicatricial, muscular or tendinous.

Reduced epiphyseal separations
Foot affection
Weak feet
Congenital or acquired club-foot following correction
Metatarsalgia
Sprains
Scolioses
Regenerating peripheral nerve injuries
Paraplegias
Hemiplegias
Ataxias

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   - Arterial hypertension.
   - Arterial hypotension.
   - Atelectasis.
   - Postoperative empyemas.
   - Chronic pleuritic adhesions.
   - Neurasthenia.
   - Hysteria.
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   - Torticollis, congenital and spasmodic.
   - Fractures, following reduction.
   - Dislocations, following reduction.
   - Amputations, postoperative.
   - Ankylosis, fibrous.
   - Arthritis, chronic.
   - Contractures, cicatricial, muscular or tendinous.

the eighteenth century references are made indicating that it was even then appreciated that occupation was of definite value in neuropsychiatric cases. Benjamin Rush, in 1801, in speaking of methods of treatment for nervous disorders advocated teaching the roots of the mechanical arts. In 1822, Dr Wyman, Superintendent of McLean Hospital, stated that amusements provided in the establishments for lunatics such as chess, backgammon, ninepins, swinging, sawing wood, gardening, reading, writing, music, etc., afforded exercises both of body and mind and had a powerful effect in tranquilizing, breaking up long associations of days and inducing correct habits of thinking as well as acting.[1] The annual reports of superintendents of many insane asylums during the last hundred years point out the same trend of thought and are more or less unanimous in their approval of work as a remedial agent in improving the physical well being and composing the restless and excited conditions of the patients.

It is interesting to note that the type of work selected during the early years in using occupation as a curative agent consisted largely in agricultural labor, carpentry and drawing and painting. Later the diversional occupations were made use of, but as late as 1878 Dr Hoyt of the Iowa State Hospital stated that no greater diversity of employment, no more methodical application of this form of treatment could be reported than was done fifty years ago. However, during the past fifteen or twenty years, definite advancement has been made not only in the selection of suitable work for the insane and blind but also in the principle of applying suitable occupation for those of sound mind but physically handicapped. In 1910 *Invalid Occupation* by Susan B Tracy appeared showing the value of occupation for the sick with lessons increasing the resourcefulness of the nurses in keeping a patient occupied during illness. In 1914 the Massachusetts General Hospital established a medical workshop as a hospital department for the use of chronic out patients. The shop was equipped for the manufacture of cement flower pots, seats, sundials, garden accessories, and during its first year made itself self-supporting.

At Sharon, Connecticut, a convalescent home for cardiac cases was started where cement work similar to that done in Massachusetts General Hospital was made the work being graded so that moderate and controlled exercises for the patient could be given and at the same time profitable occupation afforded. In Massachusetts the conversion of an old barn into the now well known Devereux Mansion where occupation was the chief remedial agent proved to many that through the agency of work much could be done.

During the last ten years in many hospitals for chronic conditions such as tuberculosis, orthopedic lesions and cardiac diseases and in innum

[1] Quoting from Dunton

CHAPTER VII

OCCUPATIONAL THERAPY

WILLIAM V HEALEY

Introduction —For many years medical men have realized that prolonged illness or disability, particularly in patients requiring prolonged hospitalization, was frequently accompanied by a mentally depressed or lethargic state, which was rarely overcome until the patient was able to return to his former occupation, or at least some occupation It was not an uncommon sight, ten years ago, in entering a hospital ward, to see twenty or more patients, in all stages of illness, either lying quietly in bed gazing at the usual blank hospital walls, or sitting up aimlessly, occasionally reading but for the most part doing nothing Nurses, at times noting certain patients more depressed than others, would give them heaps of cut gauze to fold and this simple measure frequently transformed a much worried and depressed individual, lying disgruntled in bed, into a more or less cheerful one, sitting up in bed and, while working, talking to his neighbor

A few thoughtful persons prior to this time, with keen insight into the psychology of the sick, advocated keeping hospital patients busy They appreciated, of course, that the seriously ill or in a critical condition could do no work, but the large percentage of hospital patients during their stay in the hospital frequently spent two-thirds of their time in a more or less convalescent condition, which time they could improve by suitable work, thereby not only improving themselves physically but psychologically preparing themselves for their return to their former or other occupations For many years occupations of various sorts have been sought for the blind and for those suffering from mental disorders, and the beneficial effects in these types of cases have been too well recognized to require more than passing comment But it has been the work accomplished by these types of cases that has done so much toward the establishment of the idea that occupation is one of the best means we have for aiding in the recovery of the sick or maimed

Manual work has been well recognized for many years as a therapeutic agent in the treatment of mental diseases In the medical literature of

rehabilitation of those applying for such assistance. This law was passed by Congress in June, 1920, and is known as the "Industrial Rehabilitation Bill." Up to the present time thirty-four States in the Union have accepted the offer of Congress and have appropriated varying sums for the rehabilitation of those crippled by accident or disease, making it possible for any individual to receive the required training to fit him for work that he can do. In New York State the appropriation of $75,000, with a like sum received from the Federal Government, provides the means with which physically handicapped persons may receive vocational training to fit them to return to some occupation—the only limitations being in those cases of aged or helpless individuals, those confined in penal institutions, epileptics, feeble-minded and those under the age of fourteen. The rehabilitation work is carried on under a Commission consisting of a Commissioner of Education, a member of the State Industrial Commission and the State Commissioner of Health.

To-day one hears many terms used in conjunction with the care of the sick and maimed other than medical. Occupational therapy, ergo therapy, functional reeducational rehabilitation therapy, vocational training and rehabilitation, curative occupation and countless others, all of which border upon and merge into each other, yet differ from each other in the stage of illness at which they are utilized and the manner in which they are applied. In order that we may adequately understand the principle of this type of therapy we should clearly define what is meant by the term occupational therapy and by the associated terms above-mentioned.

Occupation is work. Work used to improve either the physical or mental functions of a patient is occupational therapy. Ergo therapy is work therapy and hence synonymous with occupation therapy.

Functional reeducation, as used in conjunction with restoration of those physically maimed, is the physical restoration of function by means of appropriate physiotherapy, such as baking, hydrotherapy, massage, electricity or gymnastics. Where a remedial exercise is given in the curative workshop through the movements required in carrying out definite trades or occupations, this type of work borders closely upon occupational therapy. In a monograph on *Occupational Therapy Applied to the Restoration of Function of the Disabled Joints* Baldwin states that "occupational therapy is based on the principle that the best type of remedial exercise is that which requires a series of specific voluntary movements involved in the ordinary trades and occupations, physical training, play, or the daily routine activities of life." In this the author has limited occupational work to those suffering from disabled joints, but a broader conception of its usefulness must be appreciated. Functional reeducation, if applied to the restoration of disabled joints and accomplished through the medium of exercise in the curative workshops, is certainly occupational

erable private and semiprivate sanitariums, occupational therapy, through awakening the will and affording encouragement, has aided greatly in shortening the time of convalescence and the maintenance of the spirit of accomplishment

The stimulus of the War brought out the usefulness of this remedial agent very forcibly, when those previously active in private life were suddenly brought into hospital environment so maimed that, in many cases, prolonged hospital convalescence confronted them I do not doubt that, had no definite plan of occupation been outlined for them, they would have evolved a means of their own to keep themselves occupied Prolonged hospitalization without some sort of occupation is demoralizing The ennui seen in everyday life among those with insufficient or uninteresting occupation is magnified in tho e of unsound body who cannot seek the diversions available for those sound in body The establishment of occupational work throughout the army hospitals did much for the maintenance of the morale of the patients

At the Walter Reed Hospital, where *curative* workshops were established under the direction of Major Bird T Baldwin, the effort to utilize occupation as a definite means in the restoration of disabled function was successfully accomplished The movements required in special types of work were carefully studied and patients lacking function in one or more joints were put to work at occupations requiring these very movements For example, in limitation of pronation and supination in the forearm, no better form of exercise could be given than the use of the screw driver in doing electrical work, which at the same time affords interesting and instructive occupation for the patient

In New York City, the Red Cross Institute for Crippled and Disabled Men, founded through the generosity of Mr Jeremiah Milbank, opened up a new sphere of action, and has developed into a model institution *for the rehabilitation of the crippled and disabled* *This* Institute aims to train vocationally the patient around his handicap, so that in spite of his physical infirmities he may become partially, if not wholly, self supporting The Institute affords a school wherein those receiving out patient hospital treatment may be trained during their period of disability for one or more hours during the day, so that, by the time they have reached the maximum physical improvement, they will be ready to take up suitable gainful occupations

Recently the Federal Government, appreciating the dire need of such necessary reeducation for the crippled or disabled, has appropriated a fund whereby the individual States upon appropriation of a sum of money, will receive a like sum from the Federal Government for the vocational rehabilitation of those disabled through accident or disease In each state there has been *appointed a State Commissioner for Vocational* Rehabilitation, whose duty it is to spend these appropriations in the vocational

rehabilitation of those applying for such assistance. This law was passed by Congress in June, 1920, and is known as the 'Industrial Rehabilitation Bill.' Up to the present time thirty four states in the Union have accepted the offer of Congress and have appropriated varying sums for the rehabilitation of those crippled by accident or disease, making it possible for any individual to receive the required training to fit him for work that he can do. In New York State the appropriation of $75,000 with a like sum received from the Federal Government provides the means with which physically handicapped persons may receive vocational training to fit them to return to some occupation—the only limitations being in those cases of aged or helpless individuals, those confined in penal institutions, epileptics, feeble-minded and those under the age of fourteen. The rehabilitation work is carried on under a Commission consisting of a Commissioner of Education, a member of the State Industrial Commission and the State Commissioner of Health.

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therapy, for not only does the patient functionally improve the range of motion in his joints, but he receives a training in mental coordination which, if anything, is of more permanent value than the physical restoration However, there are many cases totally unsuited for work in the curative workshops which can be reached and benefited by occupation appropriately applied

Rehabilitation therapy, as its name implies, may include both the physical rehabilitation and the vocational rehabilitation, and for this reason is a rather confusing term Vocational rehabilitation, or vocational training, is the training of one physically or mentally below par, in work by means of which he will later be able to make his livelihood Physical rehabilitation on the other hand, includes all the medical, surgical and physiotherapeutic means for the restoration of function in a patient and should not be confused with occupational therapy

If one appreciates that occupational therapy is applied to those chronically ill or maimed, as an adjunct in improving their physical and mental well being while disabled, either by means of curative workshops or by less active work at looms or in bed, and that the advancement made as the patient improves physically is in the taking up of vocational training and fitting him for suitable work as a means of earning a livelihood a more definite understanding of the principle and purpose of occupational therapy will be obtained

The selection of work suitable for a patient may vary from the cutting of paper puzzles in bed to the use of the electric torch in acetylene welding but it is nevertheless, work, requiring a varying degree of mental and physical coordination on the part of the patient, and it is the beginning of the training in mental or physical coordination that dignifies the work accomplished as occupational therapy

TYPES OF REMEDIAL WORK

Work, as a remedial agent, varies in the type of case in which it is used, as well as in the stage at which it is started One might divide such work into three stages, as follows

1 Occupation for those bedridden
2 The intermediary stage, or occupation for ambulatory cases requiring hospitalization
3 Vocational training

Among the *bedridden* it is generally understood that those acutely ill require rest and are not benefited in any way by attempts at even diversional occupation But there are many bedridden patients among chronic cardiacs, tuberculous cases and hopeless cripples, interested in work which they are able to do and which stimulates and endows them with a spirit

FIG 1 —RAKE KNITTING AND TAPESTRY MAKING

of hopefulness and of accomplishment that can be gained in no other way The dissatisfaction of being unoccupied in bed offers time for

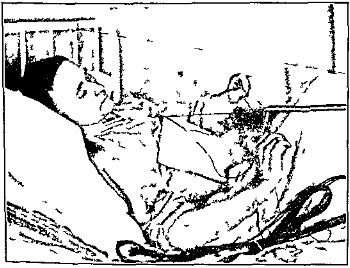

FIG —FELT MAKING

thought and introspection and complaint concerning the unfortunate s condition The improvement in the powers of coordination the lessening of the intro pection and the requirement of fixing the attention to the

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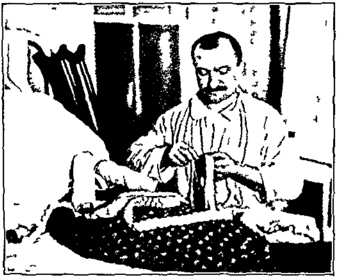

FIG 4—BRAIDING RUGS WHILE CONVALESCING

The intermediary stage comprising by far the greatest number of patients who are benefited most by suitable occupation, includes that large

FIG 5—WEAVING ON HAND LOOMS IN THE WARD

class of patients requiring institutional treatment but not actually confined to bed In every surgical ward in many medical wards in all orthopedic institutions or service and in convalescent and tuberculous

work at hand engenders an improved spirit with the desire of accomplishment in those kept occupied. Suitable occupation requires thought in selection. The previous mental status of the patient, his age, present physical condition, likes and dislikes and personality must be considered, but once a suitable means is found, the effect produced will warrant the

FIG 3.—BASKET MAKING WHILE CONFINED TO A WHEEL CHAIR

effort spent in finding it. Following is a short list of occupations suitable for those confined to bed:

Puzzles	Stencil work
Chip carving	Metal work
Modeling	Leather work
Making flowers	Drawing
Basketry	Designing
Crocheting	Painting
Knitting	Embroidering
Belt making	Reading
Small loom work	School work

finger, to the blacksmith's sledge so that ordering work with the use of a hammer would be as ill advised as the prescribing of a tonic, and leaving it to the patient to administer to himself any stimulant he might think necessary

At times patients will resent doing the diversional forms of occupation, and will respond admirably to the stimulus of curative workshop occupation when it has been explained to them that the use of certain tools or machines, when used as directed, will help the stiffened hand or weakened leg Most patients however respond to the creative idea of producing something and once they can be interested in the production of an

FIG 8—SCARFS TABLE COVERS BASKETS TOYS ETC PRODUCTS OF OCCUPATIONAL THERAPY

article it is difficult to draw them away from it until it is finished They must be carefully watched as patients recently out of bed will often fatigue themselves at the beginning of their work so that it is very difficult to get them to return to it Many forms of occupation have been made applicable to this class of cases and the more experience the director of this work has the greater diversity of occupations he will find suitable for them

The space allotted to the work within the confines of hospitals varies in different institutions from the equipment that may be kept in a ward to whole buildings of curative workshops but the same principle of sustained effort may be secured from the humblest equipment as from the most elaborate.

Occupations for ambulatory cases may be selected from the following

FIG 6—RUG AND TABLE COVER WEAVING AND PAINTING FOR AMBULATORY CASES

homes, great numbers of patients are to be found who respond admirably to the stimulus of work The choice of a suitable occupation for these

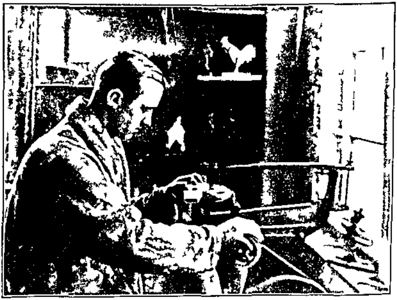

FIG 7—JIG SAW WORK FOR AMBULATORY CASES

people is extremely important As Barton has pointed out, a hammer may vary from the small jeweler s hammer which may be strapped to a

finger, to the blacksmith's sledge so that ordering work with the use of a hammer would be as ill advised as the prescribing of a tonic, and leaving it to the patient to administer to himself any stimulant he might think necessary

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Occupations for ambulatory cases may be selected from the following

list which have been found suitable in many different institutions utilizing occupation as a remedial agent

Loom work (making small blankets, rugs, table-covers, scarfs, bags, etc)

- Basketry
- Cabinet making
- Bookbinding
- Leather work
- Hammered brass work
- Jewelry work
- Pottery
- Cement work
- Light gardening

Salmon gives the following as equipment for the beginning of a curative workshop

Smith shop
- Forges tools etc for 10 men

Fitting shop
- 1 screw cutting lathe
- 1 sensitive drill
- 1 polishing machine
- 1 electric motor (1½ horse power)
- Swages and tools for 8 men

Leather blocking
- Sewing machine
- Eyeletting machine
- Tank
- Galvanized iron and tools

Tailor's shop
- 3 sewing machines
- Tools for 10 men

Carpenter shop
- Selected tools for 15 men
- Bench screws
- Special tools not for general use
- Woodturner's lathe

Machine shop
- Electric motor (8¼ horse power)
- Shafting
- Brackets etc

Cement shop
- Metal molds
- Tools for 12 men

General
- Drilling machine
- Grindstone
- Screw cutting lathe
- Fret saw worker's machine and patterns
- Circular saw bench

When a patient, physically handicapped through accident or disease is forced to abandon the thought of return to his previous occupation, he is faced with the problem of finding some work which he will be able to do Ordinarily this would mean either working for a lower wage or for less time, either of which would mean a decreased income, lower standards of living and discontent All who have seen patients pass through this change realize the marked psychological change such individuals undergo, and yet there are but few for whom profitable productive occupation cannot be found, if they are able to get about and still possess the desire to work

To do this, the problem of vocational training must be started in the hospital Occupational therapy, used intelligently, instills into the patient the necessity for continuance of productive activity and prepares the way for vocational training The standardization of equipment, the selection

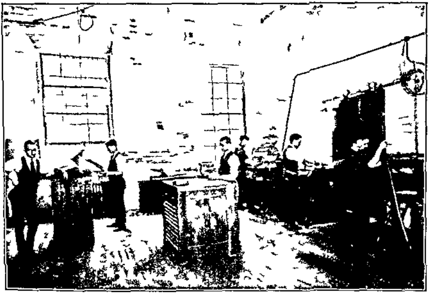

FIG 9.—PRINTING SHOP AT THE DOVER FARMS INDUSTRIES NEW YORK WHERE VOCATIONAL TRAINING REHABILITATES THE CRIPPLED AND DISABLED

FIG 10.—FLY SHUTTLE HAND LOOMS AT THE DOVER FARMS INDUSTRIES NEW YORK.

of standard design, used during the ambulatory stage, will do much to shorten the preparatory lessons in a vocational school

Institutions like the Red Cross Institute for Crippled and Disabled men and the Dover Farms Industries in New York, are to-day practically solving the vocational problems of hundreds of physically handicapped men The former institution, after a thorough study of many occupations, aims to train the handicapped individual in an occupation suited to his requirement whereby his handicap is minimized The Dover Farms Industries maintain a city center, where the handicapped are trained in productive occupations, paying the individual on production They also

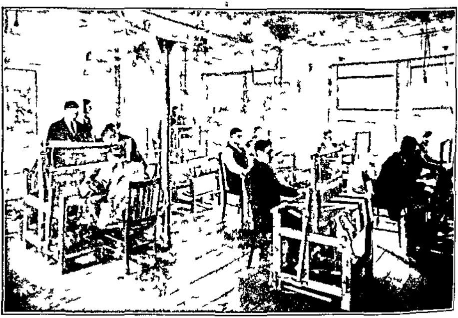

FIG 11—RUG MAKING AT THE DOVER FARMS INDUSTRIES Three cases of amputation of extremities are shown

maintain a farm where handicapped men may be kept for an indefinite period where weekly wages remunerate the individual's efforts in congenial surroundings Whether the method of rehabilitating the handicapped by adjusting an existing position in industry to his needs, or whether the method of grouping the handicapped in a community and having the total production provide a livelihood for each member of the community is the better, can only be found by meeting each individual's problem in the most sensible way so as to permit of time's economic adjustment of the problem

Application of Work—The most important factor in the application of this form of work lies in the qualifications of the director of occupational therapy Such a director must possess a deep interest in this

subject in order that he may be able to arouse the interest of his patients The suggestion by a tactless director that it is time for a convalescent patient to go to work frequently arouses an antagonism on the part of the patient against any form of occupation which is difficult to overcome On the other hand the more versatile, tactful director will first interest himself in the patient's everyday psychology finding out his likes and dislikes and having become somewhat acquainted with him suggest that they do something together—the most reasonable approach and one most frequently assented to by the patient

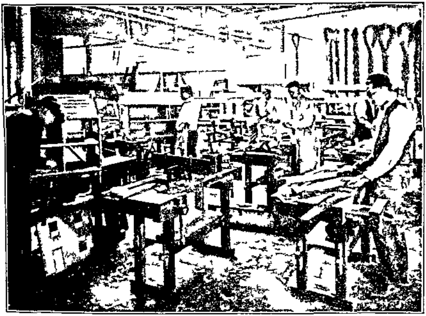

FIG 1 —VOCATIONAL REHABILITATION AT THE DOVER FARMS INDUSTRIES CABINET SHOP

The type of patients in the orthopedic hospitals differs materially from that found in hospitals for mental diseases and the approach to a patient in each instance will vary The more versatile the director the easier it will be for him to suggest an occupation suitable to the patient's requirements It is as harmful to start a patient on a piece of work that is difficult for him as it is to order an overdose of strychnin The director should moreover, possess an unbounded patience a vast amount of energy, an appreciation for effort even in such cases where the product of the patient's efforts is hopeless from a commercial point of view The accomplishment of producing even a poorly made article where the effort is appreciated frequently will stimulate the patient to further effort

and awaken an interest in the work which grows into a desire to return to regular occupation

The application of occupation requires time, of which the average convalescent, or chronically ill patient, has an abundance. It is time in which the patient is wealthy, and whereas commercial articles to be salable must be turned out in the greatest of numbers in the shortest space of time, the product of the occupational therapy department should be one whose value is based on its excellence of work in order to compete with the commercial market. A well-done piece of hand hammered brass has a market which cannot be infringed upon by the machine-made article, and the monetary value of such an article is measured only by its excellence. It is *important, therefore, that*

1 Useful articles be produced

2 Articles be produced for which a market exists

3 Effort be made to produce articles which, because of their excellent workmanship, form and color, are to be commended

The space required for the application of the work will vary according to the type of institution in which it is used. Whereas, in the tuberculosis hospitals much of the work will be done in bed, the requirement for space, other than for small storage rooms, is not great. However, in the orthopedic institutions or in the general hospital or surgical services, the curative workshops require space for small machinery, for large looms and for different types of work which cannot be dispensed with. A small beginning usually leads to more extensive plans than were formerly thought of, so that, in beginning such a department, sufficient space should be allowed for natural development. In the Reconstruction Hospital in New York, where industrial accidents and diseases are cared for, one entire floor of an eleven-story building, now in the course of construction, is to be devoted entirely to occupational therapy

The financing of a department of this kind is frequently one of the objections raised in starting such work. Like all other departments of a hospital, it requires money to run it. Some institutions have appropriated a small sum to start the work, placing in charge of the department an experienced occupational teacher who works under the direction of a medical adviser. As assistants to the teacher, volunteer aids can be secured, who will give part of their time to the teaching of the different crafts. As products materialize in the department, the assistants dispose of them through sales, bazaars or through commercial houses, who sell the articles on a commission basis. The cost of the material is deducted from the selling price, the patient receiving the balance for his work. In other institutions, the patient makes one article which he is permitted to sell for himself on condition that he produces another like article for sale by the institution. Still other institutions have a fixed price, which is given for the work produced, the institution disposing of all articles

at its own price The choice of method of disposition of the articles is, however, not the most important phase of the work and is usually met with in some way by the director of the department The effect, however, on the patient of securing monetary return for his efforts cannot be dispensed with, and, to my mind is an important factor in readjusting him and hastening his return to more profitable employment

The National Society for Promotion of Occupational Therapy has recently stated the following basic principles of occupational therapy

1 Occupational Therapy is a method of treating the sick or injured by means of instruction and employment—productive occupation

2 The objects are to arouse interest courage and confidence exercise mind and body in healthful activity overcome functional disability and reestablish capacity for industrial and social usefulness

3 In applying occupational therapy system and precision are as important as in other forms of treatment

4 The treatment should be administered under constant medical advice and supervision correlated with other treatment of the patient

5 Treatment should in each case be specifically directed to the individual s needs

6 Although some patients do best alone employment in groups is usually desirable because it provides exercise in social adaptation and stimulating influence of example and comment

7 The occupations selected should be within the range of the patient's estimated interests and capabilities

8 As the patient s strength and capability increase the type and extent of occupation should be regulated and graded accordingly

9 The only reliable measure of the value of treatment is the effect upon the patient

10 Inferior workmanship or employment in an occupation which would be trivial for the healthy may be attended with the greatest benefit to the sick or injured Standards of entirely normal persons must be maintained for the proper mental stimulation

11 The production of a well made useful and attractive article or the accomplishment of a useful task requires healthy exercise of mind and body gives the greatest satisfaction and thus produces the most beneficial effects

12 Novelty variety individuality and utility of the products enhance the value of an occupation as a treatment measure

13 Quality quantity and salability of the products may prove beneficial by satisfying and stimulating the patient but should never be permitted to obscure the main purpose

14 Good craftsmanship and ability to instruct are the essential qualifications of the occupational therapist Understanding interest in the patient and an optimistic cheerful outlook and manner are equally essential

15 *Patients under treatment* by means of occupation therapy should also engage in recreational or play activities It is advisable that gymnastics and calisthenics which may be given for habit training should be regarded as work Social dancing and all recreation and play activities should be under the definite head of recreations

*Maryland Psychiatric Quarterly January 1919

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CHAPTER VIII

ELECTROTHERAPY

HARRY EATON STEWART

GALVANIC OR CONSTANT CURRENT

Sources—Galvanic electricity may be obtained from the town lighting supply, which, if alternating in type, must be changed over by motor transformers It may also be derived from power generated on the premises or from the chemical action of cells or batteries Some one of these sources of current is always near at hand

Apparatus—It has seemed to the writer that too much space has been given by authors on electrotherapeutics to a detailed description of apparatus The physician is now able to obtain a number of well-constructed types of galvanic machine The leading manufacturers are providing service to keep such apparatus in working condition therefore it would seem that emphasis should be placed upon the physics physiological effects indications and technic rather than upon any detailed description of machine construction

Physics—A very brief sketch of the physics involved in the galvanic current is necessary to the understanding of its physiological effects and will serve as a basis for the comprehension of the other types of current The earth contains a certain amount of electricity, which amount is taken as the standard for comparison with the amount contained in other objects An excess of that contained in the earth might be considered as higher potential or a positive charge and will flow to the earth when a body so charged is connected to it by a conductor or ground and the flow will continue until the electrical charge of the body is equal to that of the earth Electricity will pass from a body charged with a higher potential to one with a lower potential when so connected until the charge in each is equal When we desire this flow or current to be constant we must find some means of creating and maintaining a difference in potential This may be accomplished through chemical action in the galvanic cell or by mechanical action in the dynamo The simplest form of generating an electric current is in the single cell which will now be described

Galvanic Cell—This consists of a container partially filled with dilute sulphuric or hydrochloric acid termed the electrolyte, into which is placed a rod of zinc and a rod of carbon or copper Chemical action is at once set up, the acid reacting upon the zinc with the formation of new chemical substances, among them zinc sulphate and hydrogen Some of these elements travel toward one pole and some toward the other, according to their electrical affinity So long as this chemical action of the acid on the zinc pole continues, the principal movement of elements toward the carbon or copper pole is maintained, charging it with a higher potential, and it is therefore designated as the positive pole, the zinc becoming the negative If to these poles outside of the cell a conducting wire is attached an electrical current will flow from the positive to the negative poles thus completing the circuit Thus it is seen that the difference in potential within the cell constantly created by chemical action is equalized by the flow of current along the wire When this chemical action becomes weaker or ceases, there is a corresponding weakness and cessation of the current outside of the cell The dry cells follow the same principle of construction except that the electrolyte is made of some solid or semisolid substance and the container is of unbreakable material

Batteries—To obtain more power than can be generated in a single cell two or more may be connected together to form what is known as a battery In medical practice we usually desire high voltage and low amperage, to obtain which, the cells must be connected in series In this case the positive pole of one cell is connected with the negative pole of the next cell and so on to the desired number In this way the amperage remains that of one cell, but the voltage is multiplied by the number of cells connected Occasionally, however high amperage is desired rather than high voltage, the cells are then connected in parallel that is all the positive poles are joined together to form one terminal and all the negative to form the other

Electrical Terms—The simplest definition of the various terms met with in studying this subject should be constantly kept in mind Among them are

Volt—The unit of pressure of electromotive force generated by the standard wet cell (V)

Ohm—The amount of resistance offered to the passage of a current through one thousand feet of one tenth inch copper wire (R)

Ampere—The quantity of current which the force of one volt will drive through one ohm in one second Since in medicine we usually deal with a small quantity of electricity, we commonly use one one-thousandth of this amount or the milliampere (m a) as our standard

Ohm's Law—In an electric circuit the strength of the current is

inversely proportionate to the resistance The quantity of current (amperes) C, is equal to the electromotive force (volts) E, divided by the resistance (ohms) R or C equal $\frac{E}{R}$ No more simple way can be found to illustrate these terms than by comparing the flow of electricity to that of water Let us suppose that we have two containers connected by a pipe each partially *filled with water* If one is above the level of the other the water will flow from the upper to the lower container The difference in the level illustrates the difference in electric potential and the quantity of water which flows through the pipe represents the amperage The speed or pressure of the flow would correspond to the voltage, while the resistance offered by the walls or turns in the pipe resembles the ohmage in an electric circuit

It is stated in Chapter XII that the constant current is the one whose main effect is chemical For all practical purposes the slight thermal effect can be disregarded When the galvanic current is passed through bodies complex in their chemical make-up such as human tissue chemical changes immediately take place Complex molecules are dissociated and new combinations formed from their elements Atoms become electrically charged and the ions already in the tissues begin a movement across the electric field or pathway according to their different affinities As will be later shown these chemical effects, produced by the passage of the galvanic current through the tissues are what determine its employment in therapeutics They are complex and many of them relatively unimportant but the important and useful chemical changes may be used advantageously and the others disregarded

Physiological Effects—The chemical changes just referred to may be brought about within the living body almost as easily as outside of it It must be clear that we are dealing with a powerful agent by means of which to effect tissue process Indeed within its very evident limitations we have the advantage of more direct and more easily localized effect than is possible with drugs by internal administration Since the ions within the tissues do move according to their selective polar affinity it must be evident that the selection of the proper pole is absolutely essential and the differential effects must be clearly understood The importance of this cannot be overestimated for as might be inferred in most conditions where the application of the positive pole is indicated the negative would be distinctly harmful and vice versa The selective action of the galvanic pole upon drug ions will later be taken up The effects which they exert upon living tissue are as follows

Positive pole
1 Produces vasoconstriction
2 Is sedative to sensory nerve endings, relieving pain
3 Hardens newly formed tissue especially scar

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Electrical Terms—The simplest definition of the various terms met with in studying this subject should be constantly kept in mind. Among them are:

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Ohm—The amount of resistance offered to the passage of a current through one thousand feet of one-tenth inch copper wire. (R.)

Ampere—*The quantity of current which the force of one volt will drive through one ohm in one second.* Since in medicine we usually deal with a small quantity of electricity, we commonly use one one-thousandth of this amount or the milliampere (m.a.) as our standard.

Ohm's Law—*In an electric circuit* the strength of the current is

the positive pole Certain complex productions are broken up by an electrolytic process and when dissociated the newly liberated ions also start a definite migration following the same principles

New elements then formed have a modifying effect upon the tissue During their passage through the tissues many of these elements are swept away in the blood and lymph channels through which they attempt to make their way, and thus their elimination from the body is hastened Clinically the result of this process is sensed by the marked relief from fatigue in any given locality after a few minutes application of the galvanic current Pain is lessened by the sedative effect of the steady movement of certain ions in the vicinity of the sensory nerve endings those attracted to the positive pole predominating in this effect The slight tingling or stinging sensations that are produced when the galvanic current is applied are undoubtedly due to this fact There is no doubt that the sudden starting of such ionic movement through the motor nerve endings causes the preliminary contraction, or twitch which the muscle gives when the galvanic circuit is closed or made The steady movement of these ions when the current is kept at even strength does not cause any further muscle contraction When however the strength of the current is suddenly changed or the current is turned off there results another muscle twitch Therefore we may assume that in order to produce a muscle contraction in the vicinity of either pole it is necessary to bring about an abrupt starting or stopping of ionic movement If the current is reversed very slowly, we obtain a response from the sensory nerve endings as the result of the movement of the ion first in one direction then in the other When however this reversal is abrupt the ionic movement will result in a stimulation to the motor nerve endings and the muscle substance, which results in a contraction The more rapid the reversal of polarity or the application and removal of the current becomes beyond the number of fifty or so per second which is physiological the less vigorous will be the muscle contraction responses When these changes reach a frequency of approximately five hundred per second no relaxation time is allowed and the muscle becomes tetanized As we shall see in the study of high frequency currents when these changes are increased to over ten thousand per second the ions remain practically stationary, there being more time for appreciable movement in either direction, and as we would expect all motor responses on the part of the muscle cease from that point on

As might be expected there is a difference in response to current variations at the two poles At the region of the positive pole or anode there is a decrease in irritability and a lessened contractile response while at the negative pole or cathode the irritability is increased and the contraction more marked The stimulation of the central nervous system may be brought about by a removal of the fatigue products in the

Negative pole

1 Produces vasodilatation
2 Is both stimulating and irritating
3 Softens and reduces the amount of scar tissue

Polarity Tests —Fill a glass partially full of salt solution, a 1 or 2 per cent solution is ordinarily used on all galvanic electrodes is sufficiently strong The galvanic machine is then connected up, with the metal cord tips firmly fastened at the terminals on the machine Turn on a moderate amount of current and allow the other tips of the two cords to drop into the solution about a half inch apart Very soon bubbles will be seen on one of the metal tips This is the *negative* pole Another test is to apply the cord tips to moistened pink litmus paper, when a blue stain will appear at the negative pole It should be *remembered that with several types of wall plugs, the polarity on* the apparatus may become reversed, therefore, such a machine should be retested for polarity each time after it is connected up to the current Where central contact plugs are used, or it is not necessary constantly to disconnect the machine, the terminals into which the cord tips are inserted may be permanently marked as the polarity will not change

The resistance of the human dry skin is about five thousand ohms, *we moisten the skin with saline in order to reduce this resistance as much* as possible

Therapeutic Uses of Galvanic Current —In therapeutic practice the galvanic current may be employed to

1 Introduce drugs into the tissues—so-called medical ionization

2 Relieve local or general fatigue by removing waste products through the rearrangement and redistribution of ions already in the tissues

3 Destroy tissue through the formation and concentration of caustic elements at the point of entrance or exit of the current—surgical ionization

4 *Alleviate pain through sedative effect upon sensory nerve endings*

5 Produce muscular contraction when used in its interrupted, wave or sinusoidal form

6 *Stimulate the central nervous system*

7 Reduce the size of hypertrophic and adventitious tissue within certain definite limitations

The subjects of medical and surgical ionization will be taken up and discussed under their separate headings The relief of local and general fatigue is accomplished in this manner As soon as the galvanic current is passed through the tissues, there is at once instituted a movement of certain of its *elements or ions Those carrying a positive charge move* in the direction of the negative pole, while those negatively charged seek

uneven degree of moisture while they still seem wet enough to reapply without soaking When the small disc electrodes are used with a hooplike metal rim they are apt to become concave and the patient receive a concentration of current from the rim rather than from the whole electrode They must be kept flat by cotton or a suitable covering of gauze Where gauze is used as the covering not less than twelve to fifteen layers should be applied In the application of electrodes to patients it is advisable to have plenty of absorbent cotton at hand This may be cut into sizes slightly larger than the electrodes, well soaked in saline and then placed on the skin with the electrodes over them These pieces of cotton may be discarded after each treatment thus obviating the necessity of sterilizing the electrodes themselves

The Patient—If the patient is appearing for the first treatment it is well to explain to him, briefly something of the nature of the treatment and the sensation he will experience It is quite usual to find that patients at first fear ' electric shock and will not properly relax unless mentally *prepared and made comfortable On the treatment table* the part to be treated must be well supported and the patient should be able to relax perfectly Blankets, rubber sheeting or bath towels should be provided to keep the patient warm and his clothing dry Next the skin covering the areas where both the active and indifferent electrodes are to be applied should be carefully examined All evidence of ointments oils liniments or other applications when found should be removed by soap and water or alcohol Some of these substances are apt to facilitate skin burns and all oily media are poor conductors of electricity If any abrasions are found they should be covered with dry gauze and adhesive plaster The electrodes of proper size and shape having been selected and thoroughly soaked in a 1 or 2 per cent saline solution they are ready to be applied The pads of absorbent cotton are soaked in the same solution the excess of moisture gently squeezed out and placed evenly on the skin The electrodes are applied over them the appropriate cord tip inserted and the whole bound snugly on with elastic webbing except in such positions as the back of the shoulder where the patient may conveniently lean against the electrode thus holding it in place A bath towel may be bound on or held by the patient to keep the electrode in place In any event a perfect contact must be made to prevent burn Everything is now ready for the treatment The current should be turned on *slowly* and the operator should watch the patient as well as the meter When a stinging sensation is felt by the patient it is well to wait a few minutes before raising the current to maximum Whenever this sensation is excessive and the current strength is not too great in proportion to the size of the smaller electrode the current should be turned off slowly and the patient's skin examined for possible abrasions which were overlooked

same manner The slight improvement in the circulation which it is possible for us to obtain does not account for the sum total effect of stimulation we are able to procure For instance, in galvanism of the brain there must be, in addition, a distinct increase in the metabolism of the individual neurons of the central nervous system

Treatment

Technic—All the switches on the apparatus should be turned off, the wall plug inserted and the machine examined to see that all connections are tight The cords should next be attached to their terminals and should constantly be watched to see that they are in good condition The frequent soaking of the ends of the cords for polarity testing and treatment is apt to rust even the best material of which their metal center is made A break in the wire is not usually visible through the covering but, if present, will interfere absolutely with the success of the treatment The polarity should then be tested by either of the methods above given and the cords marked so that they will not become confused

Electrodes—Electrodes of the proper size and material should be at hand sterilized if possible In selecting the proper electrodes to be used the following points should be kept in mind

1 The indifferent electrode should be, roughly, double the size of the active electrode and it may be placed in any convenient position, usually a short distance centrally and opposite to the latter

2 The size of the active electrode depends upon the area which it is desired to treat, and it is placed in the closest possible proximity to that area

3 The strength of the current desired must also be considered in determining the size of the active electrode, because it is not safe or comfortable to use more than 1½ milliamperes of current per square inch of this active (smaller) electrode

4 The shape of the electrode is also determined by the area to be treated For instance, in a treatment over the sciatic nerve an electrode very long and narrow should be selected

Most of these electrodes are constructed with a metal screen back, to which the cord tip insert is soldered and to the face of which felt or other soft covering is attached This metal screen back may rust and break, with the result that an undue concentration of current is applied to the patient, if the size of the felt has been taken as the gage for determining the proper current strength Many of these heavy felt coverings take a considerable time to soak through and properly transmit the current They should never be placed on end to dry, as gravity will produce an

uneven degree of moisture while they still seem wet enough to reapply without soaking When the small disc electrodes are used with a hooplike metal rim they are apt to become concave and the patient receives a concentration of current from the rim rather than from the whole electrode They must be kept flat by cotton or a suitable covering of gauze Where gauze is used as the covering not less than twelve to fifteen layers should be applied In the application of electrodes to patients it is advisable to have plenty of absorbent cotton at hand This may be cut into sizes slightly larger than the electrodes well soaked in saline and then placed on the skin with the electrodes over them These pieces of cotton may be discarded after each treatment thus obviating the necessity of sterilizing the electrodes themselves

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If the treatment is to continue for longer than twenty minutes, unless a good thick cotton pad has been added, the electrodes should be re-moistened to prevent excessive skin irritation This irritation is caused by a concentration of salts at the applied poles These do no harm if kept in proper solution by sufficient moisture of the electrodes On the other hand, if the electrodes become dry, a severe irritation of the skin may result which may prevent further treatment for several days At the end of the time prescribed the current is turned slowly, gradually and completely off The electrodes are then removed and the patient's skin examined, dried and dusted with talcum powder There should be no more *than a slight redness of the skin under the electrodes and a slight, comfortable* feeling of warmth in the parts treated Electric burns are usually the result of metal touching the skin during the treatment They are extremely hard to heal and are inexcusable When they do occur they should be treated as any other burn

Precautions —1 Patients should receive little, if any, sensation from the treatment A slight tingling is all that is permissible The meter reading alone cannot be depended upon Occasionally, during the treatment, the meter reading will increase This may be due to the fact that certain ions are being introduced which tend gradually to reduce the resistance of the skin and subcutaneous tissue to the passage of the current More often the meter needle will gradually return toward zero This occurs when the skin is becoming dry or when certain ions, such as the metals, are being introduced which form insoluble elements with the ions already in the tissues

2 As stated before, watch carefully for abrasions and, if found, properly cover them

3 In treatments about the head, especially in galvanism of the brain, it is very necessary to have a current of absolute steadiness That derived *from batteries or through water resistance is more safe* than current taken from the main The current must be turned on very slowly, never in large amounts, and the patient watched constantly for signs of distress or vertigo Turning off the current at the end of the treatment must be done with equal care

4 In treating with the labile, or movable, electrode, it is better not to lift the electrode from the skin but to stroke firmly and rhythmically Removing the electrode from the skin changes the treatment from that of constant to that of interrupted galvanism with quite different results

5 Be particularly careful not to allow any metal to come in contact with the patient's skin Watch, especially, in this regard patients who are restless or who move the part under treatment in any way

6 Anesthetic areas, such as those covered by scar tissue and other skin *areas just* distal to scars, must be treated with extreme care Keep in mind the unreliability of the meter reading The important point is

that dryness of the electrode causes great skin resistance and the concen tr ition of caustic elements, while there is a retrogression of the needle There is also an increase in the unpleasant skin sensations which the patient experiences In the anesthetic condition we are considering he does not receive this sensatory warning and therefore we must be doubly cautious It is well to use le s current and shorten the time of the treat ment even to the point of getting less effect per treatment

7 If any adjustments of electrodes or of the patient s body are required, the current must be turned slowly and completely off before they are made

8 Erythema other than a slight reddening or increased ensitivity of the patient s kin after treatment requires that these conditions sub ide before further resumption of treatment

The Galvanic Bath —The galvanic bath both local and general, is becoming widely used It has several advantages over the application of the current by means of the ordinary electrodes In the first place every square inch of skin immersed in th water becomes electrode surface hence relatively larger amounts of current may be applied with a mini mum of disagreeable sensation Secondly perfect contact is of course a sured and we do not have to watch for contact of metal to the skin or spend unnecessary time properly to adjust the ordinary types of electrode

Local Treatments —The e may be given in any container made of non-conducting material such as porcelain or earthenware Such con tainers are manufactured of suitable size and shape to accommodate a single extremity On the inside of the container is placed a plate of carbon or metal which extends down into the water and conducts the current from the cord to the fluid An ordinary ponge electrode may be placed over the edge or on the bottom of the container if this built in place electrode is not provided The indifferent electrode may be another similar container or of the ordinary felt type and applied over the lower back or behind the houlder To follow the principles already outlined, it would have to be a fairly large pad to equal or exceed in area the square inches of skin surface immer ed

Schnee Bath —This is a well constructed eries of four containers for each of the extremitie two three or four of which may be connected up at the same time The temperature should be 99 to 100 F and kept as nearly as possible constant There h uld never be any change made in the volume of water after the current has been turned on as such change may result in sensations alarming to the patient It is necessary carefully to protect the clothing from becoming wet during the treatment Bifurcated cords may be u ed so that the po itive and negative pole may be each applied to two containers at once As in the other types of treat ment the current is turned slowly on and off, and the same slight tingling is a good guide to the amount of current to be used

General Galvanic Bath—In general body treatments, there should be sufficient water in the tub to cover the body to the shoulders, and no change made in its volume once the treatment has been started Occasionally, the sinusoidal or faradic, with or instead of the galvanic, may be given by the same technic for general tonic effect Before the patient enters the bath, the temperature of the water should be tested by the attendant introducing his hand or elbow into it The desired quantity of current may also be tested in this way, after which it is turned completely off and the patient placed in the bath A depressing or fatiguing effect follows too prolonged or too strong treatment and, on succeeding days, accordingly, it should be modified The patient should never be left alone during the body bath treatment, as he is very helpless and, should any connection be loose or any change in the current flow occur, he may become frightened and the treatment end disastrously Frequent inspection should be made of the apparatus and of its connections

General Galvanization—In certain cases where the galvanic bath is impractical for any reason, a general treatment may be given by means of an especially constructed chair, which is usually of the reclining type, constructed with metal electrodes on the back, seat and arms These plates are provided with fixtures to hold the tips of the cord from the apparatus This chair is arranged so that one or more parts of the body may be treated at one time, though it is generally used for entire body treatments The electrodes may be prepared as already described When these treatments are given for sedative or mild tonic effect, the current should never be strong enough to produce more than slight tingling To produce the greatest results in therapeutics, the galvanic current must be administered with carefully selected and individual technic It cannot be employed with best results in large clinics requiring hastily administered treatments to large numbers of cases

IONIZATION

Definition—Ionization, ionic medication or cataphoresis is the introduction from without, or the internal rearrangement or concentration within, the tissues of the ions of various chemical elements, by means of the selective polar action of the constant galvanic current

History—Several physicists had suggested the possibility of utilizing this property of the galvanic current during the last years of the nineteenth century Leduc, of Nantes, in 1900, was the first to utilize ionization in the treatment of disease Since that time there has been a rapid increase in its employment in therapeutics W J Turrell, of England has done very valuable work in clarifying and systematizing the physical

and chemical principles related to this subject, and G Betton Massey, of Philadelphia has made many valuable contributions to the literature

Chemistry—Certain acids bases and salts in solution are broken up by the passage of an electrical current through them, into atoms which take on different electrical charges These are termed ions The e ions or wanderers are more or less un table and enter easily into new chemical combinations The term ion was fir t given to the electrified atom by Faraday Leduc illustrates the action of the constant current in dis sociating chemical bodies and their sub equent polar migration by com paring the process to a dance The partial association of the positive and negative ions is represented by the partners on the ballroom floor The action of the passage of the current in separating and putting them in motion according to their electrical affinity is compared by him to the cessation of the music and the assembling of the ladies at one end of the room and the men at the other

Cations are ions containing a positive charge introduced at the po itive pole or originating in the pathway of the current, and traveling toward the negative pole They include metals and hydrogen

Anions are those ions bearing a negative charge which move toward the positive pole and include chlorin common bases and the hydroxyl group

Turrell emphasizes a point overlooked by many other writers on this subject, namely that the chemical action at and immediately below electrodes is electrolytic in nature and is not the same as that which occurs in the interpolar pathway The dis ociated molecules in the ionic state do not exhibit their former chemical affinity which is temporarily replaced by the electrical charge When they reach the immediate vicinity of the pole toward which they are attracted they lose their electrical charge and again become chemically active as before The velocity of movement which the various ions exhibit differs widely hydrogen being by far the most rapid Many of the effects we produce are due to the extremely rapid migration of the hydrogen and hydroxyl ions *The less the atomic weight the faster will the ions travel*

McGill quotes three experiments illustrating the importance of the e polar effects

1 Fill a glass tube with absorbent cotton soaked in saline At one end in ert a mall plug of cotton moistened with potassium iodid In the other end place a similar plug wet with starch solution Attach the cathode to the potassium iodid end and the anode to the starch end and turn on the current The potassium iodid will be dissociated into its elements potassium and iodin and the iodin will be driven toward the anode where the starch will turn blue Reverse the polarity and no such effect occurs

2 Paint two areas on a limb with tincture of iodin Place a moist ened electrode over each area and turn on the current The brown stain will disappear under the cathode but not under the anode

3 Soak two electrodes in a solution of cocain hydrochlorid, apply to the skin and turn on the current *The skin over the anode will become* anesthetic, that under the cathode will be unaffected, showing that it is not simple absorption of the drug but selective polar action which has occurred

The belief that drugs are carried into living tissue is further proven by the appearance in the urine and saliva and by the deaths of animals with the use of the alkaloids

W J Turrell in performing the starch and iodin experiment with a slightly different technic call attention to the fact that iodin ions are passed through a considerable quantity of starch, staining only that directly under the positive pole Chatsky's experiment tends to prove Turrell s contention A more complicated experiment, where strychnin sulphate was passed through the bodies of two rabbits, placed in circuit, further demonstrates this fact The strychnin ion was not chemically active while passing through the first rabbit, but only when reaching the opposite pole in the body of the second rabbit did it lose its charge, become chemically active and cause the death of the animal An attempt to pass the salicyl ion through a leg about to be amputated also failed to *demonstrate the presence of the drug in the deeper tissues* Several American workers including Massey, still believe that there is some ionic effect in the deeper tissues and they have obtained clinical results which it is hard to explain on any other basis As many of the tissues we desire to affect are comparatively superficial and the condition of these *tissues has been repeatedly improved by ionization, we may assume that we* have a procedure of real clinical value

Turrell protests against the term ionization being employed to designate any given treatment, in the sense in which this term has commonly been used, stating that ionization is the dissociation of molecules in solution without the application of any external force *Although the point is well* taken, the common use of this term to designate a method of treatment is followed rather than to introduce a confusion of terms

Technic —The number of drug ions driven into the tissues will be proportionate to

1 The current density
2 The duration of the treatment
3 And inversely as the atomic weight of the ion used

The time factor is of the utmost importance It requires from 30 to 60 minutes of the application of a current of moderate strength to com

plete a good ionization treatment. Moreover, it has been demonstrated that the best results are obtained by the use of weak solutions of drugs, those of 1 or 2 per cent being preferred.

Advantages of Ionization.—1. The desired element of the drug is driven directly into the affected tissues instead of being scattered through the system in the circulation, where but a small proportion of it can exert its action on the affected area.

2. The least desirable effect, such as those of the salicyl group upon the gastro-intestinal tract, are avoided.

3. Drugs such as cocain may be applied without introducing the needle into the skin.

Disadvantages of Ionization.—1. The greatest amount of ionizing effect takes place in the skin and subcutaneous tissue.

2. The drugs which have as yet been successfully used are few in number.

Treatments.—Under the *cathode or negative pole* we apply chlorin in the form of sodium chlorid, iodin from sodium or potassium iodid, and salicyl from sodium salicylate. Under the *anode or positive pole* we use zinc from zinc sulphate, magnesium from magnesium sulphate, lithium from lithium chlorid, silver from silver nitrate, copper from copper sulphate and morphin, cocain and quinin.

The directions and cautions given in the care and use of apparatus as outlined in the chapter on Galvanism are to be carefully carried out. The electrodes are selected and placed as for use in straight galvanic current.

Typical Treatment.—Let us use, for an example, the ionization of the sciatic nerve for neuritis.

A long narrow active electrode which will extend from the sciatic notch to the popliteal space is selected. A long, broad electrode applied to the front of the hip and thigh will serve as the indifferent electrode. They are both soaked in warm salt solution. A sufficient quantity of 2 per cent sodium salicylate is warmed to about 100° F. A layer of absorbent cotton large enough to extend beyond the active electrode in each direction, is immersed in the warm salt solution and the excess of saline gently squeezed out. The sodium salicylate is then poured over this cotton and applied directly over the course of the sciatic nerve. The active electrode is then placed over this and connected to the negative pole of the machine. Both electrodes are snugly bound on and the current slowly applied. We ordinarily use 8 to 10 milliamperes for about forty minutes. The current is then slowly turned off, the electrodes are removed and the skin is dried and powdered.

Surgical Ionization.—By this term is meant the use of the polarity effect of the galvanic current to concentrate at a small localized point certain ions which actually destroy tissue. This destructive effect is

ple a good ionization treatment Moreover, it has been demonstrated that the best results are obtained by the use of weak solutions of drugs those of 1 or 2 per cent being preferred

Advantages of Ionization.—1 The desired element of the drug is driven directly into the affected tissues instead of being scattered through the system in the circulation where but a small proportion of it can exert its action on the affected area.

2 The least desirable effects such as those of the salicyl group upon the gastro-intestinal tract are avoided

3 Drugs such as cocain may be applied without introducing the needle into the skin.

Disadvantages of Ionization.—1 The greatest amount of ionizing effect takes place in the skin and subcutaneous tissue

2 The drugs which have as yet been successfully used are few in number

Treatments.—Under the *cathode or negative pole* we apply chlorin in the form of sodium chlorid iodin from sodium or potassium iodid, and salicyl from sodium salicylate Under the *anode or positive pole* we use zinc from zinc sulphate magnesium from magnesium sulphate lithium from lithium chlorid silver from silver nitrate copper from copper sulphate and morphin cocain and quinin.

The directions and cautions given in the care and use of apparatus as outlined in the chapter on Galvanism are to be carefully carried out The electrodes are selected and placed as for use in straight galvanic current.

Typical Treatment.—Let us use for an example the ionization of the sciatic nerve for neuritis

A long narrow active electrode which will extend from the sciatic notch to the popliteal space is selected. A long broad electrode applied to the front of the hip and thigh will serve as the indifferent electrode They are both soaked in warm salt solution A sufficient quantity of 2 per cent sodium salicylate is warmed to about 100 F A large absorbent cotton large enough to extend beyond the active electrode in each direction is immersed in the warm salt solution and the excess of saline gently squeezed out The sodium salicylate is then poured over the cotton and applied directly over the course of the sciatic nerve The active electrode is then placed over this and connected to the negative pole of the machine Both electrodes are firmly bound on and the current slowly applied We ordinarily use 5 to 10 milliamperes for about fifteen minutes The current is then slowly turned off the electrodes are removed and the skin is dried and powdered

Surgical Ionization.—By this term is meant the use of the polarity effect of the galvanic current to concentrate at a small localized point certain ions which actually destroy tissue The destructive effect is

2 Paint two areas on a limb with tincture of iodin Place a moistened electrode over each area and turn on the current The brown stain will disappear under the cathode but not under the anode

3 Soak two electrodes in a solution of cocain hydrochlorid, apply to the skin and turn on the current The skin over the anode will become anesthetic, that under the cathode will be unaffected, showing that it is not simple absorption of the drug, but selective polar action which has occurred

The belief that drugs are carried into living tissue is further proven by the appearance in the urine and saliva and by the deaths of animals with the use of the alkaloids

W J Turrell in performing the starch and iodin experiment with a slightly different technic calls attention to the fact that iodin ions are passed through a considerable quantity of starch, staining only that directly under the positive pole Chatsky's experiment tends to prove Turrell's contention A more complicated experiment, where strychnin sulphate was passed through the bodies of two rabbits, placed in circuit, further demonstrates this fact The strychnin ion was not chemically active while passing through the first rabbit, but only when reaching the opposite pole in the body of the second rabbit did it lose its charge, become chemically active and cause the death of the animal An attempt to pass the salicyl ion through a leg about to be amputated also failed to demonstrate the presence of the drug in the deeper tissues Several American workers including Massey, still believe that there is some ionic effect in the deeper tissues and they have obtained clinical results which it is hard to explain on any other basis As many of the tissues we desire to affect are comparatively superficial and the condition of these tissues has been repeatedly improved by ionization, we may assume that we have a procedure of real clinical value

Turrell protests against the term ionization being employed to designate any given treatment, in the sense in which this term has commonly been used, stating that ionization is the dissociation of molecules in solution without the application of any external force Although the point is well taken, the common use of this term to designate a method of treatment is followed rather than to introduce a confusion of terms

Technic — The number of drug ions driven into the tissues will be proportionate to

1 The current density
2 The duration of the treatment
3 And inversely as the atomic weight of the ion used

The time factor is of the utmost importance It requires from 30 to 60 minutes of the application of a current of moderate strength to com

plete a good ionization treatment Moreover, it has been demonstrated that the best results are obtained by the use of weak solutions of drug those of 1 or 2 per cent being preferred

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object of these devices is to secure a sharp clear-cut *make* and *break* in the flow of the current through tissues with the general object of inducing muscle contraction

Physiological Effects—It was stated in our consideration of the galvanic current that it was the abrupt movement or cessation of movement, of ions through the muscle and its motor nerve endings that induced contraction As ordinarily used the sharp interruption produces rather a muscle twitch than normal contraction In normal muscle with its nerve supply intact the contractile responses are most sharp at that point, usually situated near the center of the belly of the muscle termed the motor point The phenomenon of the reaction of degeneration will be discussed under the heading of Muscle Nerve Testing It may be briefly stated here that interrupted galvanism will produce contraction in muscle tissue even when its motor nerve is completely severed and a considerable amount of degeneration has taken place in the muscle itself Such responses are no longer sharply localized at the motor point, but are

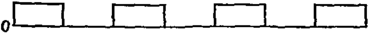

FIG 1—INTERRUPTED GALVANIC

diffused throughout the muscle sluggish and wavelike in character and with the normal polarity responses reversed The application of a sufficient amount of interrupted galvanism to induce an approximately normal contraction would be sharp and unpleasant for the patient therefore for treatment purposes this type of current has been superseded by the wave or sinusoidal currents next to be described We obtain the muscular twitch whenever the current is abruptly started or stopped with use of either the negative or positive pole When the current is started made, or the circuit *closed* the contraction is greater than when it is opened, or broken As we would expect the negative pole or cathode gives a more marked response therefore it is commonly stated that the cathodal closing contraction is greater than anodal closing contraction or KCC>ACC in normal muscle It must be remembered that occasionally the Tibialis anticus and Supinator longus are exceptions to this rule

WAVE GALVANIC CURRENTS

Sources and Apparatus—There are several types of apparatus on the market which so modify interruptions of the galvanic current that they become regular and wavelike instead of abrupt The term sinusoidal has at times been incorrectly applied to this type of current A true wave current is one which rises from zero to maximum and returns to or

prevented in our ordinary medical ionization by the size and moisture of the electrodes

The active electrodes used in surgical ionization are of metal only, and usually in the form of needles The indifferent electrode used is the ordinary galvanic pad, which is placed a short distance from the part to be treated

For strong bactericidal effect upon infected sinuses, carbuncles and boils, blunt needles or rods of zinc are sometimes used as the positive pole When so used, a pearly white color appears on the surface of the infected tissue and the bacteria count is greatly reduced

Steel needles should never be used, as they leave a black stain on the skin which is practically indelible Platinum is the best needle material Beside single needles several may be used, inserted into one fixture

Technic —The machine and different electrodes are prepared as for galvanism The needle or needles are then inserted into the mass to be treated When the current is turned on, a slight blanching of the skin is seen As a rule, only a very slight amount of current is necessary to secure this effect As soon as the blanching occurs, the needle should be withdrawn and inserted into a different part of the growth The positive pole has a tendency to harden the tissues and the needle is difficult to remove The time of the treatment in this case should be brief This effect is not seen with the use of the negative pole, which softens tissue rapidly and in a few seconds the needle can be easily withdrawn A typical example is the removal of superfluous hair The light should be so placed as to shine directly on the hair follicles A platinum needle is selected and connected to the negative pole It is then inserted gently, following carefully the direction of the hair root as far in as it will pass easily perhaps to the depth of one-eighth inch The current is then turned on and increased to 2 or 3 milliamperes, while the needle is held steadily in place In a short time, a number of small bubbles will appear at the root of the hair, then the current is turned off The hair should then be withdrawn with forceps, without the use of any force Not more than ten to twelve hairs, or one small growth, should be removed at one sitting in order to avoid unnecessary irritation to the skin and the possibility of subsequent scarring A strong current should not be used as it is not any more efficient and may destroy more tissue than is intended

INTERRUPTED AND WAVE GALVANIC CURRENTS

Interrupted Galvanic Current

Sources —Various devices have been perfected to interrupt the galvanic current This may be done by means of a metronome, with the use of an interrupted handle electrode or by a key on the apparatus The

object of these devices is to secure a sharp clear-cut *make* and *break* in the flow of the current through tissues with the general object of inducing muscle contraction

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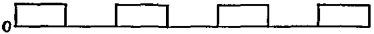

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nearly to zero and repeats in regular rhythm The polarity once fixed does not change therefore we are dealing with a series of negative or a series of positive waves These waves of current may be varied in both voltage and amperage to a fine degree by recent improvements in apparatus These variations are attained in the best type of machines by means of cams on a revolving drum, which make contacts of varying frequency, duration and intensity, between which there is a period of comparatively no current flow

Fig 2—Slow Surging Galvanic.

Physiological Effects—The result of application of this type of galvanism to patients is simply a combination of those of straight and interrupted galvanism The polarity effects of straight galvanism are present but being intermittent and not continuous are not as great in their total effects as with continuous current On the other hand the intermittent movement of ions through the motor nerve endings produces a rhythmical changing and fairly sustained stimulation which leads to good muscular contraction It is a better current for treatment purposes than interrupted galvanism but not as good for muscle testing The care and *application of electrodes* follow the same general principles already outlined This current has proved of great value in the stimulation of atonic, but otherwise normal, muscle tissue such as relaxed abdominal wall, and may be substituted within its limitations for sinusoidal or interrupted galvanism

SINUSOIDAL CURRENTS

Definition—A true sinusoidal current is one which alternates in perfectly regular opposite and equal cycles or phase The current strength rises from zero to maximum on the positive side and returns to zero,

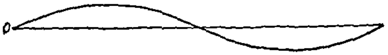

Fig 3—Slow Sinusoidal

followed by a similar rise and fall on the negative side, which may be plotted as a true sine curve

Physics—*An alternating current is conducted around the primary winding* This alternating primary current produces regular and even alternation in a secondary winding from which the patient is treated

The secondary winding reduces the voltage sufficiently for treatment purposes and might therefore be called a 'step down' transformer With the A C current also a somewhat similar arrangement is necessary to decrease both the voltage and the frequency of the current alternations It is evident that a current alternating rapidly enough for lighting pur

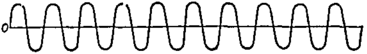

FIG 4—RAPID SINUSOIDAL.

poses would be far too rapid to employ for the purpose of obtaining muscular contractions

Physiological Effects—The sinusoidal current is one of the latest developments in electrotherapeutics and one of the most valuable for the following reasons

1 *The gradual rise and fall in current strength and the evenness of* the wave so produced is easily borne by the patient as compared to the faradic and interrupted galvanic currents

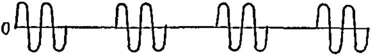

FIG 5—INTERRUPTED SINUSOIDAL

2 It has been proved that there is increased reaction when the negative pole is used where the positive has just been or vice versa This contrast is obtained in each cycle of the sine current, and gives it a distinct advantage over any form of simple wave galvanic current

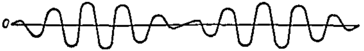

FIG 6—SURGING SINUSOIDAL

3 In a given time there is much less danger of overstimulation with this current than with the sharp and abrupt current of interrupted galvanism

4 A real stimulation of the metabolism of muscle tissue follows the application of this current, even when a perceptible contraction is not produced

There is no break in the current that is, no distinct rest period and, because of its smoothness, a much larger amperage may be used than

nearly to zero and repeats in regular rhythm The polarity once fixed does not change, therefore we are dealing with a series of negative or a series of positive waves These waves of current may be varied in both voltage and amperage to a fine degree by recent improvements in apparatus These variations are attained in the best type of machines by means of cams on a revolving drum, which make contacts of varying frequency, duration and intensity, between which there is a period of comparatively no current flow

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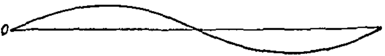

FIG 3—SLOW SINUSOIDAL.

followed by a similar rise and fall on the negative side, which may be plotted as a true sine curve

Physics—An alternating current is conducted around the primary winding This alternating primary current produces regular and even alternation in a secondary winding from which the patient is treated

tions in the healthy muscles, and by degrees, the frequency of the wave may be increased, until three contractions per second are given. During the entire course of this treatment the muscle may gain from invisible response to a slight flicker of the tendon and, finally, to a full deep contraction. After good contractions have first been elicited occasional tests should be made with the faradic current and when the response with the faradic is good, the case may be treated thereafter entirely by faradic rather than by sinusoidal current. From this regime pass on to active motion and occupational therapy.

The sinusoidal current is very useful as an aid in removing circulatory stasis through the mechanical effect of muscular contraction, following other physiotherapeutic measures, such as an application of heat which will aid in preventing the organization of the exudate in a bruised muscle. As a local substitute for voluntary exercise it has many advantages. It is being increasingly employed in the stimulation of the finer intrinsic muscles in some of the organs of special sense. The gastro-intestinal tract may be both directly and indirectly stimulated by its use. One of the very last of the electrical currents to be perfected it offers possibilities in the field of therapeutics that have as yet been but partly explored and it is expected that the indications for its use will very rapidly widen in the near future.

FARADISM

Definition.—The faradic current is an induced alternating current derived from a so-called induction coil.

History.—This is one of the oldest of the fundamental types of electrical current. The principles of magnets and their relation to electricity were first observed by Faraday in 1831. His subsequent work formed the basis for the introduction of the dynamo, the telephone and much of our modern lighting.

Physics.—This current is characterized by relatively high voltage and low amperage and is alternating in character. A weak galvanic current derived from a direct current main or from batteries passes through a coil of wire surrounding an iron core which becomes magnetized.

The induction coil is a very old and very well known piece of electromedical apparatus and although the coils produced by different makers are of somewhat different construction the general principle is the same and the current differs very little in character or quality. We have a core made up of a bundle of fine wire which is surrounded by a number of turns of a somewhat coarser wire. This is known as the primary coil. Opposite one end of this coil is a small piece of metal fastened to a rather delicate metal spring. A small screw is mounted

with the interrupted galvanic This sine wave then is able to stimulate the muscle, even in a degree too small to produce a marked contraction and without the polarity effects of the galvanic current It may be used for the purpose and to the point of obtaining a good contraction in a partially paralyzed muscle, but very few contractions are all that are permissible

Technic—The care of the machine, especially the lubrication of the rotor control, is very important, if one desires to obtain a smooth, fine current The part to be treated and the electrodes are prepared in the same way as for galvanism, the large indifferent electrode usually being placed opposite, and somewhat centrally, to the smaller testing or treating electrode The mechanism of the machines, from their nature, must be intricate and delicate and they require more care perhaps than any machines which we use except the static

Major C M Sampson, who had charge of perhaps the largest peripheral nerve clinic in Army Hospitals, has perfected a technic which can scarcely be improved upon and which deserves a detailed description The paralytic muscles are tested daily before the treatment and before receiving diathermy or whirlpool bath The opposite limb, if normal, is tested for a control

Place the patient, and especially the limb to be tested, in a comfortable position During the test, the limb is placed on glass or wood covered by a towel or blanket Test each motor point separately and compare it with the corresponding motor point on the normal limb If both limbs are affected, another person may be used as the control at first After sufficient experience this will not be necessary After determining the motor point and marking it with a dermal pencil, use a small test electrode on the motor point, with both sinusoidal and interrupted galvanic currents Gently increase the rheostat, from zero up to the point where it gives a good contraction in the normal muscle To treat the affected muscles, take a slightly larger electrode and apply it to the motor point on the affected side Start with the rheostat at zero and advance it to not over *two-thirds* of the strength that was necessary to secure a response in the healthy muscle Use a slow wave, only one or two to the second *Keep a careful daily record as to the number of waves given to the part being treated* Not over three waves should be given the first day Increase one daily until ten are being given at one treatment, after which drop to three and repeat another week If, then, a test does not show improvement, keep repeating this schedule When a marked improvement is shown, continue to increase one wave daily until twenty are reached, after which a series dropping back to ten and working up to twenty is instituted until the muscle possesses marked signs of regeneration At this point the rheostat may be advanced to the full amount which was necessary to produce vigorous contrac-

especially desired Then a small brush, consisting of a bunch of fine tinsel wire is provided to serve as the active electrode This is attached to one terminal of the machine and the brush moved back and forth lightly over the surface of the skin There is of course, not the danger of burning with this current that there is with constant current, on account of the frequency of alternations per second However, extreme moisture of the electrodes is necessary to reduce the resistance of the dry skin and reduce the unpleasant tingling

The alternations so produced are not even or rhythmical in their periodicity There are of course no polarity effects in the use of this current There have been instruments designed to measure the faradic current, but they are not as satisfactory as in the case of galvanic and high frequency current so that the sensation of the patient becomes the best guide that we have In the usual type of apparatus, this current can be modified in its strength by a set relationship between the secondary coil and the core A rough measuring scale is marked on the machine

Major Bristow, of England further modified a small portable apparatus by providing for the manual insertion and withdrawal of the core into the machine thus producing a faradic wave current, avoiding continual tetanization of muscle and perfecting an apparatus of great value for the purpose of muscle stimulation

Another modification for generalized muscular contraction aimed especially at the reduction of adipose tissue is that of Bergonie of France in which the current is applied to large muscle groups by means of electrodes on a specially constructed chair with diversified control switches on the chair itself

Since the faradic current acts on the muscle through the nerve the sharpest effect is produced by its application on the motor point of a given muscle This point as a rule corresponds to the point of entrance of the motor nerve in the belly of the muscle Therefore it follows that the active electrode should be a small one, varying in diameter from one-half to one and one half inches

Naturally for the proper testing of the interossei and similar small muscles, the sharpest possible localization is desired, while for such muscles as the biceps a somewhat larger pad may be used An indifferent electrode should be four by six inches or even larger and both electrodes chamois or felt covered are prepared as for galvanism Adequate moistening of them decreases the sensory effect There is not the danger of destructive burns with faradism which must be constantly watched, for instance, in the use of the galvanic current The faradic current also may be interrupted by a metronome by an interrupter handle on the active electrode or better still made wavelike by the core device described in the Bristow apparatus The smoother and more even the current, the better the result In any case, the current should be delivered

so that its point is nearly in contact with this spring, at about the middle of its length *One end of the primary coil is connected with* one pole of the current supply and the other pole is attached to the screw The coil and the spring are also connected The current flows from the main or batteries to the coil, from this to the spring jumping across to the screw, and so completing the circuit The current passes through *the coil* with its wire core making it temporarily a magnet which draws the small block of metal on the end of the spring toward it In doing this it draws the spring away from the screw, breaking the circuit and stopping the flow of the current When the current flow ceases, the coil loses its magnetism and the piece of metal flies back and the screw resumes its first position in relation to the spring

Physiological Effects—The faradic current is the nearest approach to the normal motor nerve impulse that we are able, artificially to obtain The usual alternation rate of fifty per second probably closely approximates the motor nerve stimulation rate It acts through the nerves themselves the stimulation being carried into the muscle at the motor point and distributed to the individual fibers by the same mechanism that is concerned with their reception of the normal motor nerve impulse For this reason, it is easily seen that, where the conductivity of the nerve is interfered with *there will be a corresponding interference* with the transmission of faradic stimulation This, it will be remembered, is contrary to the action of the interrupted galvanic current, which is able to secure a somewhat modified reaction of muscles by acting directly on them without continuity of nerve structure The type of faradic coil *which gives the most rapid alternations secures the best motor response* Slower alternating currents produce an undue amount of sensory disturbance in proportion to the motor responses secured by them. Formerly, the faradic current was widely used for it undoubted effect in increasing metabolism in completely paralyzed muscle groups where motor responses could not be elicited by its use Sinusoidal, or some form of wave galvanism is to be preferred for this purpose and the use of the faradic current reserved until the time when, as described in the section on sinusoidal currents a fairly good contraction is obtained by its use Where cutaneous stimulation is desired, a faradic brush is of value, but surface high frequency is more often used

A systemic result may be obtained where the neuromuscular system is normal but the patient with a large amount of adipose tissue is handicapped This may be burned up by the method of general muscular contractions induced by the faradic current, after the technic of Bergonie, described later in this chapter

Technic of Faradic Treatment—The faradic current is administered, in general, in the same manner as the galvanic current Moist electrodes are used, except in cases where a cutaneous stimulation is

about ten minutes These treatments are given in courses of six to ten weeks Application should be daily for the first three weeks then on alternate days starting at twenty minutes and increasing to sixty An average reduction of one-half to one pound per day may be expected and it has been the rule for improvement to continue after the treatment has been discontinued

These treatments consist in the mu cles being contracted in a rhythmical manner, in which the entire musculature of the body is concerned In this way, a combustion within the muscles is greatly accelerated, but the signs of bodily *fatigue which follow violent exercise are almost* wholly lacking Moreover, there are patients who, because of excessive weight or cardiac condition, could not take exercise which would in a marked degree aid in consuming their deposits of fat and their elimination of body wastes. For them this technic is ideal

The type of current is described as a coarse wire faradic The interruptions of the current are made about thirty per second or clo e to the normal rate of muscle fibrillation and the muscular contractions are made to correspond as closely as possible to the heart rate There is, in addition a general building up of the musculature replacing fat

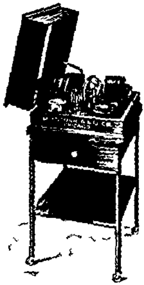

Fig 7—The Polysine Generator Combining Many Types of Contractile Currents

With increased respirations and greater activity of the kidneys, active measures to remove, as fast as possible, the cause of the obesity and to regulate the patient s routine are of course essential In many cases where too rigid dieting cau es marked weakness and where active exercise is impossible this treatment should prove of value Within a reasonable time after treatment is instituted many patients according to Titus, are willing and able to begin various types of active exercise

COMBINED CURRENTS

Several types of apparatus have been perfected whereby a measurable proportion of galvanism and faradi m may be combined in a single treatment It is evident that such a current will be of advantage where a *muscle is just beginning to respond feebly to faradism* Practically, however, the sine or the interrupted galvanic may be used, until a sufficient response permits of our treating by the faradic current alone

to the muscle only in such quantity as will procure a good contriction and for the least possible space of time in which this desired result may be obtained

Normal physiological exercise of a muscle requires a contraction, during which the venous blood and lymph are squeezed out of the muscles and adjacent tissue In the relaxation period, an increase of the arterial and capillary intake is made possible When the application of an amount of current, sufficient to produce a good contraction, is maintained beyond that point of contraction, the muscle becomes tetanized and these natural changes in the circulation are interfered with Skill in finding the exact motor point decreases the amount of current needed to obtain a good contraction Therefore, the unpleasant effect of too strong a current upon the patient's sensory nerve endings is lessened It should never be necessary to use such an amount of current as will "splash through" to neighboring muscles, the stimulation of which may be unnecessary or even detrimental A further point which should be emphasized is that the rest periods between contractions should be much longer, by four, or even eight, to one, than the period of the contractions The British electrotherapists employ two-fifths contraction and three-fifths relaxation time There is always the danger of giving too many stimulations to a weakened and regenerating muscle Of course, the faradic current is not used until a muscle has regained a certain amount of power From two to ten contractions, usually starting with the former and working up toward the greater number, is sufficient, as a rule Overstimulation is of real danger to the muscle

Example—Stimulation of tibialis anticus Make the patient comfortable with a small support under the knee With electrodes properly prepared, place the indifferent electrode, of four by six inches, under the calf of the leg, the leg resting upon it Locate the motor point and, if necessary, mark it Then, with the active electrode remaining in contact with the muscle at this point and with just sufficient current to produce a fair contraction, give from two to ten contractions according to the condition of the muscle at the time

Treatment of Obesity—Edward C Titus of New York has used a modification of Professor Bergonie's technic for a number of years in the treatment of this condition He uses a semireclining chair with large metal plate electrodes for the back and adjustable extension for the legs These electrodes are attached to the corresponding rheostat of the machine and there are two electrodes for the abdomen two for the legs and two for the anterior surface of the thighs These electrodes are all covered with a moistened covering of the same thickness They are bound on, those on the abdomen being held with sandbags Good contact of the patient and chair electrodes is essential

Contractions are given very feebly at first, coming up to maximum in

Physics—The current used in diathermy is the bipolar d Arsonval current, which has a high voltage and relatively high amperage The frequency of oscillation must be great enough not to tetanize the muscles, that is over 10 000 alternations per second To produce the desired type of current some device must be used to 'step-up both the voltage and the frequency of the current coming from the main Major C M Sampson has clearly illustrated the effect of high frequency current, by comparing it to water power somewhat as follows A stream of water six inches in diameter, having a pressure of a thousand pounds per square inch would be difficult to control and dangerous to life if it struck the body but if passed through a great nebulizing apparatus which reduced it to a fine mist, it would float and rise in the air whatever the pressure behind it Such a spray would correspond to our high frequency current and could be applied to a patient with no ill effects

The standard d Arsonval type of high frequency machine is further described as follows It contains first a control mechanism either a rheostat choke coil or autotransformer to govern the amount of current drawn from the main Secondly a 'step-up transformer, usually oil immersed which takes the low voltage current and steps it up to the desired voltage, somewhere between ten thousand and thirty thousand volts the amperage decreasing in direct proportion This first transformer does not affect the frequency of the current but only the voltage and amperage which is still dangerously high Tap-offs or leads are taken from the secondary on this transformer and connected to the primary of a second step-up transformer which may be of the Tesla type usually wax immersed, or a d Arsonval solenoid

Between the first and second transformers are placed two devices a condenser and a spark gap The function of the condenser is to store the current and to step-up the frequency The condenser usually employed in the diathermy apparatus consists of a number of metal plates separated from each other by some insulating material such as mica or glass and has a larger capacity than Leyden jars used in other types This greater capacity produces oscillations which are more sustained The condenser is placed in the secondary circuit The current may then pass into the condenser or around the metallic secondary circuit in which the resistance is low

In order to make the current enter the condenser the spark gap which is another resistance of variable amount is placed in the circuit Now the current meeting this new resistance tends to travel the reverse side of the circuit into the condenser and the condenser is charged with it, the first plate being charged positively and the second negatively by induction and so on When charged to capacity the current is discharged *en masse* across the spark gap completing the high frequency circuit

The circuit leading from the first to the second transformer must be

HIGH FREQUENCY CURRENTS

DIATHERMY

Definition.—*Diathermy*, diathermia, transthermy or thermopenetration is the bipolar application of the d'Arsonval type of high frequency current which develops a form of heat, sometimes called conversive, deep within the tissues.

History.—In 1890, D'Arsonval demonstrated that the main effect of the high frequency currents in the body was the production of heat. *The following year he used currents up to 3,000 milliamperes.* That same year, Nicola Tesla *proved that large currents of* high potentiality, currents that could light up several incandescent lamps, *might be used from* Leyden jars without harm to the body. In 1896, D'Arsonval showed that he could produce heat effects in patients with currents as low as 500 milliamperes and in 1898, began to treat diseases with these currents. The first use of the d'Arsonval current in therapeutics was made in this country by Frederick De-Kraft in 1906 in the office of William Benham Snow, of New York. In 1907, Nagelschmidt designed the first real diathermy apparatus and gave the name diathermy to this form of treatment. Tesla had suggested the use of high frequency currents in medicine as far back as 1891. We are indebted to Bordier, Lecomte, Bonniot, Wertheim, Zimmern and others, for early experimentation with this current. In 1908, von Verndt, von Preiss and von Zeyneck urged the use of the d'Arsonval current in the treatment of joint diseases. Diathermy was first used in England in St. Bartholomew's Hospital, in 1909. In 1910 Nagelschmidt used diathermy in hospital practice, but with a type of apparatus that did not give the properly sustained oscillations. From 1910 on, a number of new types of apparatus were developed, both in this country and abroad, until we now have several makes of high frequency machines combining not only a d'Arsonval current of good quality, but Tesla and Oudin currents as well.

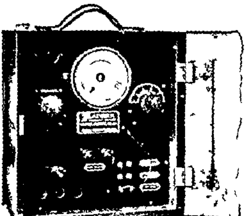

FIG. 8.—PORTABLE HIGH FREQUENCY APPARATUS DELIVERING 2,000 MILLIAMPERES OF CURRENT.

Physics—The current used in diathermy is the bipolar d'Arsonval current, which has a high voltage and relatively high amperage. The frequency of oscillation must be great enough not to tetanize the muscles, that is over 10,000 alternations per second. To produce the desired type of current some device must be used to "step-up" both the voltage and the frequency of the current coming from the main. Major C. M. Sampson has clearly illustrated the effect of high frequency current, by comparing it to water power somewhat as follows: A stream of water six inches in diameter, having a pressure of a thousand pounds per square inch would be difficult to control and dangerous to life if it struck the body but if passed through a great nebulizing apparatus which reduced it to a fine mist it would float and rise in the air, whatever the pressure behind it. Such a spray would correspond to our high frequency current and could be applied to a patient with no ill effects.

The standard d'Arsonval type of high frequency machine is further described as follows: It contains first, a control mechanism, either a rheostat choke coil or autotransformer to govern the amount of current drawn from the main. Secondly, a "step-up" transformer usually oil immersed which takes the low voltage current and steps it up to the desired voltage, somewhere between ten thousand and thirty thousand volts, the amperage decreasing in direct proportion. This first transformer does not affect the frequency of the current but only the voltage and amperage which is still dangerously high. Tap-offs or leads are taken from the secondary on this transformer and connected to the primary of a second step-up transformer, which may be of the Tesla type usually wax immersed, or a d'Arsonval solenoid.

Between the first and second transformers are placed two devices, a condenser and a spark gap. The function of the condenser is to store the current and to step-up the frequency. The condenser usually employed in the diathermy apparatus consists of a number of metal plates separated from each other by some insulating material such as mica or glass and has a larger capacity than Leyden jars used in other types. This greater capacity produces oscillations which are more sustained. The condenser is placed in the secondary circuit. The current may then pass into the condenser or around the metallic secondary circuit in which the resistance is low.

In order to make the current enter the condenser the spark gap which is another resistance of variable amount is placed in the circuit. Now the current meeting this new resistance tends to travel the reverse side of the circuit into the condenser and the condenser is charged with it, the first plate being charged positively and the second negatively by induction and so on. When charged to capacity the current is discharged *en masse* across the spark gap completing the high frequency circuit.

The circuit leading from the first to the second transformer must be

tuned to resonance which is done by *equalizing the inductance resistance* to the capacity of the condenser Here, the function of the condenser is *to store up sufficient power to excite resonance in the circuit*

When the spark gap is closed or offers insufficient resistance to the current, the condensers are not charged and there is not enough energy to set up vibration in the resonators *Care of the spark gap therefore is absolutely essential to the proper working of the machine*

The Spark Gap and Its Proper Care—The care of the spark gap is perhaps the most important thing the physician has to know in the care of his machine A dirty and corroded spark gap will interfere with the smoothness and evenness of the current to such an extent as to nullify the good that might be accomplished by the treatment Where the DeKraft spark gap is used the micas must often be cleaned, rearranged and turned so as to present clean fresh edges Alcohol is the best substance to clean both the metal and the mica. Where the hooded target spark gap is used, this too must be cleaned and the end of the rod constantly freshened and kept level to insure an even current The use of cork or ground glass for better insulation, and of finer degrees of adjustment in some of the latest types of spark gap, will greatly reduce the amount of care required

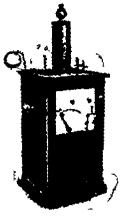

FIG 9—A STANDARD TYPE OF HIGH FREQUENCY APPARATUS

In some smaller types of machine, loose contact may occur between the metal regulator and the buttons on the rheostat when they become slightly loose by wear This may be prevented by inserting a chip of Crook's metal Some types of machine require grounding and, in this case, one must be sure the ground wire is in place

The Milliamperemeter and Its Significance—In the ordinary type of machine there is placed in circuit a hot wire milliamperemeter This meter only gives a roughly approximate idea of the amount of thermal effect the patient is getting As Mr N E Dorsey has pointed out, it measures only the total amount of the current delivered to the patient and takes no account of varying resistance within or without the body For instance if the part treated has a low resistance a strong current will be indicated by the meter without a large rise in internal temperature But, if the resistance of the part is high, for example, through the knee a smaller current will produce a more intense degree of heat Hence the meter records the total amount of current passing while the degree of heat produced depends upon the current density and the resistance of the tissue With size of electrodes and density of tissue the same, the heat produced varies as the square of the current strength Thus a

relatively small increase in current strength will greatly raise the internal temperature The reading then will vary according to the type of machine the part treated and other variations in technic in each case, and is only fairly constant for the same machine used in the same way

Physiological Effects—Diathermy is applied to the body by the bipolar method and heat is generated in the tissues in proportion to the square of the amperage used and the resistance to the passage of the current It must be clear that this is an entirely different form of heat from any heretofore used in medicine and in its effect totally different from that resulting from the application of any form of heat conducted to the skin through the air or applied directly to it This high frequency current, because of its high voltage is able to take a direct path through the tissues and is not greatly affected by their relative resistance It takes the direct rather than the easiest path one might say

We have spoken of the general construction of the d'Arsonval apparatus and the manner in which this current is generated Before considering its specific local and systemic effects, it would be well to have in mind some of the qualities possessed by this type of current A current oscillating at this extremely rapid rate of approximately a million per second is too rapid to institute ionic movement There is therefore, no muscle contraction, no ionizing effect but only sedation and the development of heat

Local Effects—There is produced a very mild hyperemia of the skin increased activity of the skin glands beneath the electrodes and lessened skin sensitivity Increased cellular activity of any given gland in the pathway of the current is produced with no tetanization of muscle, with a proper technic The sedative effect upon nerve endings has been demonstrated by decreased pain and diminished electromotor responses Active arteriole and capillary dilatation follows This increases the local arterial blood supply increases the amount of lymph passing into the tissues and quickens the venous return by lowering the capillary resistance to the blood stream Nearly all these effects are directly proportional to the amount of heat produced, and this depends again upon the size and type of the electrodes used the amount of the current and the length of the treatment Heating is intensified during the latter part of the treatment

General Effects—The distribution of the heat by the body fluids raises body temperature somewhat from 5 to 2 5° F There is a lowering of blood pressure, with mild general stimulation of the processes of metabolism and especially of elimination With heavy currents there may be a general feeling of lassitude and sometimes fatigue, especially in elderly persons A quickening of the pulse rate is often noted and a general increased activity of the eliminative mechanism

Experiments—If the autocondensation handles are held in either hand when *the current is turned on, the wrist becomes warm* with a

stronger current the arms and shoulders become hot and the wrists very hot and cramped

1 Cumberbatch noted the following temperatures in a patient using this technic with 400 milliamperes for 20 minutes There was a rise of temperature Fahrenheit, as follows front of the wrists 6°, front of the elbow 4° axilla, 2 4° mouth, 2 6°, groin, 1 2°, and popliteal space 3 The rise of temperature in the mouth and in distant parts was due to the heating of the blood stream and the maximum temperature was in the wrist where the current density was greatest

2 In a second experiment the same technic was used with 500 milliamperes to maximum tolerance, which gave a temperature in the front of the wrist of 20 The flexor side of the arm was 3 to 4° warmer than the extension side which increased to 6° when the arms were flexed With the electrodes over the chest and abdomen, no rise of body temperature was secured

3 D Arsonval demonstrated that all parts of a saline solution were equally heated He further showed that in passing diathermy along the hind legs of a rabbit the deeper tissues as well as the skin, could be coagulated by strong currents

4 Maragliano passed diathermy through the thorax of a dog in which a small electrical lamp had been placed The lamp became incandescent

5 A series of experiments with liver illustrated the conductivity of saline solution to the diathermy current Strips of liver were cut 6 by 1 by 1 inches In each case 450 milliamperes were used for four minutes (a) Crook s metal electrodes 4 inches long and 1 inch wide were wrapped around both ends the liver placed in a dry dish and the current turned on The liver was thoroughly cooked through and was especially well done in the center (b) Both liver and electrodes were placed in the salt solution and the cooking was very much less marked (c) One end was raised as before the other end placed on the electrode on the bottom of the dish The liver was cooked except on and under the electrodes (d) The free electrode was simply placed over the edge of the dish down into the saline and the results were the same as in C, but the cooking not quite so thorough These experiments indicate that the direct application of plates is more efficient than through the water but that a true diathermy may be obtained through saline into which an electrode has been placed

6 Cumberbatch describes a case in which the palms were moistened with saline and the thermometer placed between them The electrodes were applied to the back of the hands One thousand four hundred milliamperes for six minutes gave a 7° F rise of temperature It is to be noted here that we have two extra layers of skin with their added resistance and the rise of temperature is therefore greater than it would

be in the middle with the same mass of tissue, as, for instance, in the forearm

7 In a large growth on the back of the neck, with the indifferent electrode on the chest, an active circular electrode three-fourths of an inch in diameter, was placed on the growth A thermometer was thrust into the growth one inch below the active electrode The temperature rose to 110 F

8 Illustrating edge effect When two electrodes are placed side by side or end to end the hottest point is between them Two electrodes were placed on the back of the forearm the nearest edges one inch apart The temperature of the skin under the center of the plates rose 8 F on the edge facing the opposite electrodes, 21 F

9 Saberton experimented with a dish of egg albumin Two electrodes were placed in the albumin at opposite sides When a heavy current was turned on suddenly the coagulation first appeared immediately beneath the electrodes When turned on slowly coagulation took place first in the center

10 Flexible metal electrodes were bound on the opposite sides of a large potato Fifteen minutes of moderately strong current were applied The potato was cooked in a diamond shaped area, broadest in the center

11 The temperature of the brain can be raised by diathermy through the skull Gloetta and Waser[1] showed 1 C rise in the lateral ventricle of a dog after diathermy for ten minutes

From our clinical experience with this current and from the foregoing experiments we may conclude

1 That diathermy does develop a deep-seated and real heat within the tissues

2 While this heat is great enough to coagulate protein, there is no danger in its application to normally vascularized tissue, because the circulation of the body fluids diffuses the heat

The amount of heat developed depends upon the resistance of the tissues and the current density With a given milliamperage the current density is equal if the electrodes are of the same size and the greatest amount of heat is obtained halfway between them, when the current is slowly turned on If electrodes of unequal size are used the current density is greater a short distance below the smaller electrode Thus we are able to localize the desired effect In the application of diathermy to the fingers or toes advantage may be taken of its condition through salt solution

The Machine—To give satisfactory diathermy treatments an apparatus must be capable of delivering at least 2 000 milliamperes of cur

[1] Arch f Exper Path u Pharmak Jun 1914

rent Fortunately, there are several types easily portable which are of sufficient power The larger machines for office practice are most economical when built exclusive of many seldom used attachments No true sinusoidal current can be derived from a high frequency outfit in spite of advertisements to that effect

When the apparatus will not work, first see that *every* switch is closed and the wall plug fully inserted Next, test the circuit outlet with a lamp or other piece of apparatus If the trouble lies elsewhere examine next the spark gap taking it apart, cleaning and rearranging it, if it is of the DeKraft type, or using emery cloth on the double button variety Further taking down of the machine is inadvisible, except in expert hands *Most manufacturers are* providing good repair service where possible

Electrodes—Many types of electrodes are now on the market. Crooks or composition metal, twenty two gage, are perhaps the best for general use These may be cut into convenient sizes and shapes All four edges should be turned sharply back and rolled flat A slightly longer flap left on one end will facilitate the attachment of the clip Several electrodes should be prepared to fit easily over curved surfaces, such as the point of the shoulder This is done by slitting the side or end so that overlapping is possible Lighter weight metal is sometimes used Tinfoil is very convenient for use on the phalangeal joints with small amounts of current I prefer varieties of twenty two gage metal for general use

The solid steel disc type with handle is inflexible, requires holding in place and can only be used on flat surfaces A new type of electrode consisting of wire mesh over soft material supported by a solid metal back and applied by means of a retaining handle, has just been brought out With this handle a pair of electrodes may be quickly applied to the opposite sides of ankle or knee and will remain firmly in place German silver mesh may now be purchased in required amounts and quite durable pads made with it In some modifications of diathermy the autocondensation pad, vacuum or non vacuum high frequency electrode or hand of the operator or patient are connected to one d'Arsonval *terminal* and act as an electrode

General Technic—The patient must be made comfortable, the part to be treated well supported, and he should, if possible, be 'mentally prepared,' as before suggested The machine should be examined to make sure the spark gap is closed and the rheostat on 'I' Close the knife switch to make sure the machine is running It is well to warm the composition metal plates by placing them face upward under the radiant light or in very hot water With shaving brush and soap prepare *a heavy, hot soap lather and, applying it freely over the* electrodes place them on the skin Attach the metal cord tips with clips

or simply place them on the back of the electrodes and bind them firmly with elastic or cotton webbing or rubber bandage.

Inspect again the attachments of both cords and then close the machine switch. In the average treatment, from three to five minutes should be taken to raise the current to maximum, and two or three minutes used in reducing it. This may be done by the following method when using the DeKraft gap. Open the spark gap slowly one or two notches. It may then be closed one notch and the rheostat switch placed on the second button, when it is again slowly opened. After a moment this procedure is repeated until the third, fourth or fifth button on the rheostat, as desired, is reached and the spark gap on the second, third or fourth notch gives the desired maximum current. This procedure should take not less than four minutes for its completion.

With the hooded tungsten or turn-screw type of gap, it is often possible to place the rheostat at the desired position for maximum treatment and to depend on the very gradual opening of the spark gap above to gradually increase the current strength.

It is desirable to take about one-half as much time in reducing the current as was consumed in raising it to maximum. Neglect in the use of the requisite time for both of these measures may result in painful and generally unpleasant sensations on the part of the patient.

Where it is desired to localize the heat near one surface, select electrodes of unequal size. The current density and heat production is greatest beneath the smaller electrode. When plates of the same size are used the heat is generated in the center of the tissue mass between them. Less current is always required in dense tissue, such as the knee-joint, than through less dense tissue, such as the abdomen. It should be remembered that, since the heat varies as the square of the current in any given tissue density, a slight increase in the milliampere needle reading will give a marked rise in the internal heat produced. This is the reason why some patients are sensitive to what seems to be but a slight increase of the current.

In normal tissue with good contact, it is safe to use 100 milliamperes of current for each square inch of the smaller electrode. In very vascular tissue and where the resistance is especially low, this allowance may be increased 50 per cent. The patient's sensation is a reasonably good guide. When, however, one is treating anesthetic areas, extra precaution regarding both the contact and the current strength must be taken. Patients having arteriosclerosis must be treated with extreme caution. Their vascular elasticity is impaired and their heat diffusion sluggish. A dusky red erythema under the electrodes is a warning that the current strength must be reduced in subsequent treatments. When a pair of plates are used on opposite sides of a limb or other similar situations, it is of the utmost importance to see that they are equidistant

at all points When this is not done, an undue current density is developed between the near points which may cause a burn Such a situation may arise, for instance in the knee, by the patient changing his position *after* the plates are properly placed

The patient is unaware of the degree of sensation the treatment should produce Hence he should be instructed to inform the operator at once of any particular points of heat or faradic sensation When these unpleasant sensations occur, turn the current slowly off, reinsert soap lather with brush or finger, press the electrode down firmly a that point, reapply the bandage, and slowly increase the current again

When the current has been cut off completely by slowly reducing the current, remove the electrodes and carefully dry the skin There is no danger in the patient going outdoors with reasonable protection, by the time he is dressed and ready to leave the office

Special Technic—*Knee*—Lateral plates, while parallel, should be placed slightly nearer the front than the back of the joint, due to the sensitivity of the skin in the popliteal space Some operators "cross fire" the joint by using first anteroposterior and then lateral plates

Another method of reaching the joint surfaces is to flex the joint fully, placing one plate below and one above the patella

Heart and Lungs—Use fairly large plates, perhaps five by seven inches, and turn the current on and off with great care A steady current, as shown by a stationary needle on the milliamperemeter, must be used It is unnecessary to bind the plates on, as the patient may lie on the posterior one while the other is held gently but firmly on the chest

Brain—Diathermy of the brain has been successfully used in a number of conditions The electrodes may be applied to forehead and occiput or laterally through the parietal region *It is necessary to* employ a current of absolute steadiness One taken from a machine where there is the slightest to and fro movement of the meter needle is unsuitable Not more than 500 milliamperes should be used for a maximum of fifteen minutes Extra care and time must be taken in increasing and decreasing the current strength

Spine—It has been a common custom to apply two long, narrow electrodes to either side of the spine I do not believe that any thermal effect on the spinal cord or vertebral articulations, and but slight effect *upon the erector-spinae muscles can be obtained by this method*, because of the edge effect The major portion of the current passes along through the skin and the subcutaneous tissue between the near edges of the electrodes It is our custom to treat such cases by having the patient lie prone upon the autocondensation pad, using a movable, non vacuum, surface electrode over the spine

If more convenient, one long narrow electrode over the spine may be substituted for the movable electrodes We thus localize the heat

constantly under the electrode, obtaining the greatest current density in the structures beneath it

Extremities—A direct current may be used by applying two vacuum or non vacuum electrodes to opposite sides of the elbow or hand, for instance keeping them constantly in motion This might be termed a movable, direct technic and is useful in the elbow, on the fingers hands and feet The hands and feet can also be treated through saline solution In treating one of the proximal joints of the fingers one metal plate is bound around the midforearm the other placed in the bottom of a non-conducting vessel filled with saline and the fingers immersed in the solution Then the current is turned on and a strength of 500 to 600 milliamperes used After the other fingers are withdrawn one at a time the patient feels the increased density of heat in the affected finger which is greatest when all the other fingers are raised If the heat then becomes too great, a second finger is replaced in the saline This technic has the advantage of being entirely under the patient s control and he soon learns to regulate the amount of heat he is able to endure in the affected finger If it is desired to treat the wrist the whole hand may be placed flat on the bottom of the retainer The foot is treated in a similar fashion For the treatment of the hand and wrist, if the fingers are flexible we use a technic similar to the above, except that the patient holds the autocondensation handle in the hand instead of immersing it in the saline

Another technic in general use is the zone or cuff method for treatment of the extremities For instance in treating the elbow one electrode encircles the upper arm the other the forearm It is believed that most of the current is passed along the muscles, tendons and subcutaneous tissue and that comparatively little is obtained in the joint itself It is true that this skin or zone effect is diminished if the electrodes are widely separated or heavier currents used but, if it is the elbow or the knee that is affected the through and through technic first described seems more efficient For the sharp localization of heat close to the surface as, for instance in the gums following dental trauma or over the temperomaxillary region Eleanor Volkmar of Washington has suggested placing the patient on the autocondensation cushion The operator holding an electrode in one hand makes quick contact with the whole hand, then using the fingers as rheostats concentrates the heat beneath the tip of one finger We have modified this method by placing the operator seated on another autocondensation pad giving more freedom in the application of the treatment. A knowledge of the physics involved and the therapeutic problem at hand will enable one to still further modify the technic along rational lines

Autocondensation—This technic of general diathermy is in common use The patient is seated or lies prone—the latter preferred—on the

autocondensation mattress or pad This cushion is attached to one d'Arsonval terminal and the steel cylinder electrode, attached to the other terminal, is held firmly in both hands From 600 to 800 milliamperes are given for twelve to thirty minutes

FIG 10—AUTOCONDENSATION FOR HYPERTENSION

Precautions—There may be improper contact between electrode and skin

The current concentration may be too great, as when there is a near approach of two plates at some point

Because of local anesthesia the patient may be unaware of a degree of heat approaching pain

The tissue vascularity or vasomotor mechanism may be subnormal as in scars and arteriosclerosis

Contra indications—These are very few in number and include

Inflammatory conditions associated with walled in pus

Conditions where there is danger of instituting hemorrhage such as pulmonary tuberculosis with cavity formation and gastric or duodenal ulcers

Phlebitis usually classed as a contra indication, has been distinctly helped by diathermy in several recent cases with no untoward results

SURGICAL DIATHERMY

Definition—Surgical diathermy is the destruction of tissues by raising and localizing heat within them to the point of coagulation or desiccation It has also been termed diathermic cauterization, but differs from other

types of cauterization in that the heat is generated in the tissues instead of being conveyed to them by conduction It differs also from chemical galvanic cauterization, which is caused by the concentration of caustic ions at the poles

The *chief advantages* of surgical diathermy over other operative procedures are

1 Certain tumors otherwise inoperable may be removed
2 This procedure is practically without hemorrhage making it of special value in conditions such as cancer of the tongue
3 Danger of spreading metastases is much less than with the use of the knife, because the blood vessels and lymphatics are sealed in the procedure
4 The field of operation is sterilized by the heat developed
5 Surgical shock is in many cases less
6 The operation is rapid and often not difficult
7 Postoperative adhesions are seldom formed

Among the *chief disadvantages* of this procedure may be mentioned

1 The operator cannot bare important structures such as nerves, arteries and veins as he does in blunt dissection
2 Normal tissue is destroyed along with the malignant tissue in the same area
3 The danger of causing hemorrhage when performing surgical diathermy near large vessels is obvious
4 The liability to form keloids, in operations where large areas of skin are involved, is great
5 The tissues must be easily accessible
6 Patients who are extremely weak do not stand this procedure well.

Technic—We are largely indebted to William L. Clark of Philadelphia for the development of the technic of desiccation A general anesthetic is usually required The indifferent electrode usually a large flexible composition metal plate is well lathered and applied with the same care as in medical diathermy One must be sure in a prolonged operation, to keep plenty of soap under this electrode After the operation is completed the patient's skin is dried and powdered The active electrode consists of an insulated handle with metal center to which needles or a group of short needles knives buttons and various other attachments can be fastened

When the apparatus and electrodes are in readiness the current is turned on and the knife or button is pressed firmly into the tissue to

be destroyed From 1,000 to 2,000 milliamperes of current are used At first, bubbles of steam and gas are given off and, in the very short time it takes the tissue to coagulate, usually a few seconds, sparks will jump from the electrode to the surrounding tissues, at which point the current should be instantly turned off Intense contraction of muscles and undue stimulation of surrounding nerves occur, if the treatment is prolonged When the current is turned off after the appearance of the bubbles, the tissue is coagulated The tissues are coagulated to a depth roughly equal to the diameter of the electrode and in cross-section about half its diameter beyond the edge of the electrode When the needles are used, the depth of coagulation is much greater, but not as great in the cross section The less vascular the tissue, the more quickly will the coagulation occur When large masses are to be coagulated, it is necessary to prevent too sudden drying by dropping salt solution constantly along the electrodes

It is believed that this procedure is of sufficient value to justify the addition of this apparatus to the equipment of every modern operating room

UNIPOLAR HIGH FREQUENCY CURRENTS

Tesla and Oudin Currents—One of these two types of simple monopolar high frequency currents is generally combined with diathermy in a single apparatus The general physics of the current is somewhat the same The Tesla transformer consists of a secondary coil wound around the solenoid for the purpose of raising the tension of the current The Oudin resonator is made of a coil wound vertically on a solid base Coils on the resonator acting as the primary high frequency solenoid, and the remaining coil by resonance, thus arranged greatly increase the voltage Condensers in these types of current may be of the plate type described under diathermy, or Leyden jars The former has been described

Leyden jars are containers nearly filled with saline They are made of glass, lined inside and out with metal which becomes the armatures, the glass acting as the dielectric The inner side is connected to a rod or chain, the outer grounded The inner coat is charged by the high tension coil producing a charge of the opposite sine in the outer coat A metal conductor from the outer coat near the rod to the inner coat forms a spark gap and discharges the jar In the common Oudin resonator, the voltage of the current can be raised sufficiently to produce a strong violet brush discharge, in glass vacuum or non vacuum condenser electrodes

Vacuum Electrodes—Vacuum electrodes are known as condenser electrodes The current carried to them by a cable charges the vacuum

and inner surface of the electrode and a corresponding charge is induced in the outer surface of the glass The current induces a violet-colored fluorescence within the vacuum When brought in close contact with the skin the electrodes give a brush discharge of slightly warm and stinging character If they are kept in contact with the skin and moved rapidly, the skin becomes warm and hyperemic Vacuum electrodes of thin glass, of various sizes and shapes for surface and cavity work and shaped to a common insulated handle, are supplied by the manufacturers of the various machines These electrodes tend gradually to lose their vacuum and to become less and less efficient, but are fairly

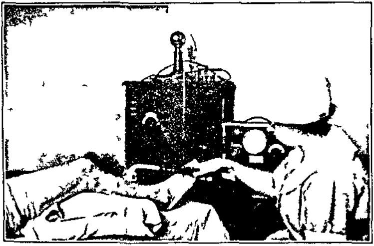

FIG 11—THE APPLICATION OF SURFACE HIGH FREQUENCY

inexpensive to replenish They have been known to explode and break in fine particles during treatments

Edward C Titus of New York has been doing some valuable work with electrodes filled with helium gas This work seems to indicate that an electrode of high efficiency and durability may in time be produced in quantity and form a valuable addition to our apparatus

A non vacuum silver lined and insulated handle electrode has been produced of a much higher efficiency than the common vacuum type This product is on the market in every form and variety It is still slightly short of structural perfection tending to oxidize after a certain amount of use But all things considered I believe it to be the most efficient electrode now at hand

Physiological Effects—Locally a counterirritant effect upon the skin is produced which is greatest at the edges of the moving surface electrode and increased by the widening of the spark gap Heat is produced

in the tissues immediately beneath the electrode and to a variable depth, depending upon the strength of the current This combined effect *stimulates greatly skin cell metabolism and the activity of the skin glands* The general effect is due to the fact that the body is completely charged and discharged with each oscillation of the current, as proved by a spark jump to a second person, if near contact is made This effect is similar to, but slighter in amount than, the systemic effect of diathermy, *that is, there is a very slight warming of the body, a relaxation of ten*sion and a general stimulation to all cell metabolism It is not, as a rule, used for this general effect but only in local heat production, the stimulation of the skin and closely underlying tissue being the usual indication for its use The two types of current differ but little in *their effects*

Technic—The spark gap and rheostat are started at zero See that all connections are tight, the electrode firmly attached the skin dry and powdered In nervous patients apply the electrode before opening the spark gap one notch In addition, the first time the patient is treated *it is well to let him first try the current on the palm of the hand*, before applying it elsewhere The reason for using powder is to take up the amount of perspiration developed and to enable the electrode to slide easily over the skin Most cables when new, can be held to the handle of the electrode in the grasp of the operator When the insulation is worn, as often is the case they should be held free from the patient's body and close to the handle of the electrode by a loop of bandage, handkerchief or towel

It is annoying to the patient to have the cable brushing the skin, but, even though the insulation is poor, he will receive no spark from the cable while the electrode is in contact with his skin When the electrode is being applied or removed, he may receive a hot spark from some part of the cable touching the skin, producing a burn The electrodes should be cleaned with warm water after each treatment, being careful in the non vacuum type not to get water into the electrode through the opening for the metal loop on top With the skin powdered and the electrode in place, the spark gap and rheostat are gradually increased to the desired strength of the current

In general this current is useful in producing hyperemia through its thermal effect in the neck, the joints of the hand and foot and other superficial tissues, where diathermy electrodes are difficult to apply It is useful, as stated for stimulation of the skin glands and, to a slight degree, for general stimulation along the spine In the latter case a wide spark gap and low rheostat is used If the current is on before the electrode is applied to the skin it should be applied very quickly, kept in fairly rapid motion, the excursions of which must be great enough *continually to cover an entire new surface of skin, otherwise* some of

the electrode is in con tant contact with the same area of the skin, re ult ing in overstimulation The electrode may be removed quickly with the full current on. It is not necessary as is the case with diathermy, gradually to work the current down before discontinuing the treatment

The subject of high frequency should not be di mi ed without a word regarding the mall toy machines with which the country is flooded. Efficacy in the treatment of almost every ill the flesh is heir to is claimed for them If potent as claimed they would be dangerous in the hands of the laity There can be no question that they hare the danger of other similar procedures that of delay in proper diagno is and treatment of conditions where such delay may be erious or fatal to the patient This cheap type of apparatus has only a low frequency of oscillation, no resonance or quality of current The current it produces resembles the rich smooth powerful current of a well made machine in the same way that the tone of one cheap fiddle re embles the combined strings of the symphony orche tra It is a afe rule in electrotherapeutic practice, as el ewhere, that the best work can only be done with the best tools

STATIC ELECTRICITY

Definition.—Static is a form of electricity of extremely high voltage and low amperage It is developed by friction is hard to insulate and has distinct polarity

Uses—Static was cla sified under the mechanical currents By means of it we are able to produce mild and superficial or deep and powerful contractions of mu cle ti ue which is to some extent hared in by other types of cells so that it has been at times called cellular ma age By means of no other currents or combinations of currents nor by the use of any other type of physiotherapy can like effects be produced to the ame degree In routine office practice there are a number of di advantages in the u e of this current among them are

1 The expense of a well made and turdy type of machine

2 The amount of room es ential to its proper u e

3 The awe and dread which the ize and power of the apparatus provokes in the uninstructed in this really most safe of all currents.

4 The exploitation of the undoubted psychological effect of this current by those who do not understand it or its legitimate uses

History—We are indebted to the late William J Morton, who first used static about 1880 and more recently to William Benham Snow Frederick DeKraft and Major Chris M Sampson of this country and W J Turrell of England for the further introduction and standardization of static electricity in therapeutic practice

in the tissues immediately beneath the electrode and to a variable depth, depending upon the strength of the current This combined effect stimulates greatly skin-cell metabolism and the activity of the skin glands The general effect is *due to the fact that the body is completely charged* and discharged with each oscillation of the current, as proved by a spark jump to a second person, if near contact is made This effect is similar to, but slighter in amount than, the systemic effect of diathermy, that is, there is a very slight warming of the body, a relaxation of tension and a general stimulation to all cell metabolism It is not, as a rule, used for this general effect but only in local heat production, the *stimulation of the skin and closely underlying tissue being the usual* indication for its use The two types of current differ but little in their effects

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damp weather, ice and salt may be used to condense what moisture has gotten into the machine It is advisable on dry, sunny days to take off the ends of the case and admit fresh dry air A yardstick wrapped in cloth and dampened with banana oil will clean and remove all moisture from the plates After several applications, however, a film may form on them which requires removing by scraping Each day the rods and terminal balls should be gone over with hot flannel cloths keeping them bright and dry

Charging —Place the charger chain on the opposite terminal after the ground wire has been removed Turn down the charger rod separate the small terminals about half or three-quarters of an inch and turn the charger handle rapidly After several minutes of spark discharge across the terminals turn on the motor If the spark discharge keeps up after charging rod and chain have been removed and continues when the terminals are separated two or three inches, the machine is properly charged It may be necessary to repeat this procedure several times If still unsuccessful attention must be given to changing the air inside the case or cleaning the plates

Polarity —Static is another type of current in which the polarity effects are distinct and of great importance There are three convenient tests for polarity

With a spark gap of about three-quarters of an inch it will be noted that one end of the stream of sparks appears light in color, this denotes the *positive* pole

When the terminal distance is increased to three or four inches, this light color appears at the *negative* terminal

Perhaps the most reliable test is to separate the terminals some four inches run the machine at full speed and approach the terminal with one end of a dry wooden stick The most convenient rod to use is one from one foot and a half to two feet in length The stream of sparks at the *positive* pole will follow the movements of the end of the stick at the negative pole it will not The differential polarity effects will be stated in a description of the separate types of current

It must be kept in mind that the polarity may become reversed While this most often happens when the machine requires recharging it will occasionally happen from dampness without apparent complete loss of charge No static treatment should ever be given without the operator s certain knowledge *as to its polarity at that time*

Physics and Physiological Effects —The best types of apparatus develop a voltage ranging from 100 000 to 800 000 and an amperage of from 1/4 to 2 milliamperes This extremely high potential and minute volume of current is not approached in any other type of electricity As stated the main effect is that of tissue contraction not alone confined to muscles The current is diffused easily rapidly and completely

Apparatus—The two principal types of static machines built in this country are, in the opinion even of foreign workers, superior to any made abroad They consist of two separate compartments, in the smaller of which two revolving glass charger plates with brass brush collectors are placed, turned either by hand or motor In the larger section are a series of glass or fiber plates arranged in pairs and revolved practically always by motor power The size, number of pairs and possible speed of the plates, all are determining factors in the efficiency of the apparatus

The type of machine having been chosen, the next thing to consider is its *location* The static machine should be placed, if possible, in a room by itself and in any event, at as great a distance as possible from the walls and other apparatus A point emphasized by Sampson is the proper grounding of the machine He states that a ground wire should be suspended at least three feet above and one or two feet in front of the machine and should not come nearer than this distance to it In this way leakage is reduced to minimum Connection from the ground to the machine may be made by using a piece of heavy copper wire three or four feet long with a flexible chain and hook at the lower end for attachment to the proper pole of the apparatus It must be so arranged as not to swing close to the other pole of the machine or to the patient on the platform The other end of the ground wire may be connected to a radiator or water pipe or to a copper rod driven into the ground Both the end of the wire and the object around which it is twisted should be freshened with emery cloth and the connection made tight by several turns or by soldering Loose connections quickly oxidize, offering increased resistance to the grounding of the current and interfering with the efficiency of the apparatus The ground wire should never be attached to the frame of the machine nor laid on the floor beneath it, as in that way serious leaks of current are apt to occur

An insulated platform of wood with glass legs should be provided While any wooden chair may be used, it is most convenient to have one of the adjustable reclining type made entirely of rattan in *which no* steel or other material is used A second grounding must be made by a flexible chain which will reach to the treatment platform from as nearly as possible the opposite direction from the machine

Care of Apparatus—The inside of the case must be kept as nearly damp-proof as possible by tightly fastening in each section of it In addition it is necessary to keep drying material inside of both charger and plate sections We use for this purpose wooden boxes, lined and covered with unbleached muslin and filled about half full of dry lump lime The covering prevents the lime powder from being distributed through the machine When this lime has absorbed moisture and has swollen to *the size of the box, it should be refilled* Turrell uses for this purpose shallow basins partly filled with sulphuric acid In particularly

Morton Wave—The wave current has been termed ionic, molecular and mass massage It is dependent for its effects upon the very powerful and extremely penetrating vibrations produced This perhaps most valuable of static modalities was first described by Morton in 1890 It is a decongestor of tissue removing and to some extent, breaking up exudate not yet firmly organized For deep-tissue drainage no form of massage or contraction produced by other currents can approach its efficiency

Treatment Technic—The negative pole is grounded, and the electrode connected to the patient is attached to the positive pole The wave may be given with or without the use of Leyden jars In commencing, the treatment should be moderate and the spark gap quite short The best electrodes for general use are the composition metal twenty two gage recommended for diathermy A number of these may be cut in varying sizes and shapes using a clip to attach them to the wire or inserting a hook through a hole made in the longer turned back end of the metal A broad U shaped electrode to exclude the patella is convenient for applications over the knee One electrode may be slit from the middle of one end and overlapped to fit the point of the shoulder It is not necessary to obtain the perfect contact required in diathermy, although a reasonably good contact and the use of warm soap lather makes the treatment more comfortable for the patient Morton wave is never applied over bony prominences

The physiological effect of the current is modified by a number of factors The best rate of spark jump and consequent tissue contractions is three to four per second This rate is maintained when the spark gap is gradually lengthened by steadily increasing the speed of the plate revolutions It is customary to find in treatments of tender areas that the patient s tolerance gradually increases so that a wider spark gap with deepened effect can slowly be obtained without increasing discomfort

The local effect produced is proportionate to the width of the spark gap and inversely as the size of the electrode A good insulation of the platform is essential to the securing of a good result The length of the treatment varies from ten to twenty minutes It is unwise to use the wave current in an attempt to break down organized exudate, such as that following a muscle bruise unless it has been preceded by diathermy Exudates near the smaller joints and in tendon sheaths are better reached by means of the static spark Such organs as the liver, spleen and prostate may be easily and efficiently treated with the wave current

Sparks—The sparks are applied to patients by the direct and indirect method The *direct* method is not as efficient is more stinging and painful and used only to reach deep-seated lesions The platform is connected to the negative pole the positive side grounded The ball elec-

throughout the entire body and through the air and other relatively poor conductors This diffusion is dependent upon the second main quality of the current namely, its tremendous voltage or potential and is shown by the raising on end of the hair, and in many other ways This raising of the hair is due to the fact that, the hair being charged with the same polarity as the rest of the body, its free end is repelled by this like charge In the contraction of muscle tissue it is not necessary to pay any attention to the motor point as the perfect diffusion and high potential affect the entire muscle and easily produce a good contraction I have spoken in other sections of the often neglected but important point of reassuring the patient especially when, for the first time, an electrical current is applied to him There is no type of current in which it is so essential to perform this duty as it is in the case of those derived from the static machine To carelessly inform a patient that he is about to receive some half million volts of electricity, without explaining the freedom from danger which the minute amperage of static assures, is to be unfair to him Absolutely no ill effect, other than an unpleasant sharp minute blow from a spark, can be obtained from this apparatus The spark is a cold one The hand may be held between the terminals with impunity Matches cannot be ignited in the pathway of the spark Again, I repeat, it is the safest of all electrical modalities used in medicine

When giving sparks, I often explain to the patients that it has a slight stinging character, quite similar to snapping an elastic band on the skin, with no burn or after pain It is often found that pain and tenderness from previous tissue engorgement is so greatly relieved that patients request more sparks rather than fewer The other types of static if properly given, are not in the least unpleasant Some writers advise giving milder types first, even though they may not be as efficient, in order to accustom a nervous patient to the apparatus before using sparks I have found this unnecessary and prefer to use very short indirect sparks gradually increasing them to the required severity This contractile effect is that of practically all types of static modalities and their minor differences will be described separately under each type

All static modalities raise blood pressure somewhat and should be avoided in cases of marked hypertension Its employment in low systolic pressure and associated conditions is distinctly indicated

The patient should remove all steel which touches the skin Garter clasps, hairpins and steel ribbed corsets should not be worn Both operator and patient should lay aside their watches during treatments

Modalities

The different types of current derived from a static machine include wave, sparks, effluve, induced, and simple charge

sprains without rupture of ligaments, are improved with astonishing rapidity A certain general toning up effect upon the general nervous system follows a treatment of sparks along the spine

Effluve—The static effluve brush blue pencil or breeze, produces extremely mild and more or less superficial contraction of tissue Its effect is distinctly sedative when given by the ordinary method It may be made rather irritating when the electrode is applied closely or through the clothing The sensation which the patient receives is that of a cool breeze striking the skin

Treatment Technic—The terminals should be opened to their fullest extent The positive side is grounded The shepherd crook held by the patient or placed on the platform is connected to the negative pole Quite a variety of electrodes have been used in giving this form of treatment The DeKraft pencil is to be preferred for all general use It consists of a fiber cylinder filled with asbestos, at one end of which is a blunt brass point and at the other a ring for connecting it with the second round chain Willow or ash sticks have also been used Where it is desired to diffuse the effect produced an ordinary whisk broom may be used as the electrode A loop of the second ground chain should be held in the grasp, while the electrode or the chain may be partly wrapped around the operator s body The point of the electrode is held at a varying distance from the skin, depending upon the amount of current, usually about three inches away and moved rather rapidly by the flexion and extension of the wrist

Boudet of Paris found that the area of superficial skin effect was about one and one-half times the distance between the electrode and the body Therefore it is concentrated by close approach The bluish color which appears between the point of the electrode and the skin is probably due to electrified dust particles which become fluorescent A crown piece with brass points on a stand may be used to localize the effect on the head, and when given to women patients all combs and hairpins must be removed and the hair should be braided It should be placed quite a few inches from the top of the head The effluve current is especially useful in acute nerve pain to gently remove tissue congestion over bony prominences and in locations where wave and sparks are difficult to apply A typical example would be its use to promote absorption of the hemorrhage in a case of black eye The use of it to promote the healing of ulcers has been recommended but this is better done by other means Headache and insomnia particularly when associated with low blood pressure are amenable to treatment by the static effluve

Induced Current—This type of current first described by Morton, is also used to drain tissues It is applied by the bipolar method the patient being connected with the outer two coats of the Leyden jars the inner coatings of which are connected to the terminals Its local

trode with handle is applied from the second ground chain for direct sparks

Indirect Sparks—This is the method commonly used Its effects are much more sharply localized than with the wave current, but the effect of muscular and cellular contraction is much the same

Treatment Technic—Snow connects the positive pole to a metal plate, some ten by fourteen inches placed upon the platform, and grounds the negative Sampson Turrell and others apply the shepherd crook from the negative pole to the platform with the positive not grounded In every case the spark is given from the ball and handle from the second ground chain The intensity of the spark may be modified by varying the speed of the machine, by opening up the main terminals or by drawing off part of the current through the operator's foot, placed close to the platform or resting on the edge of it The wider the spark gap and the faster the machine is run, the longer and more powerful will the spark become The hook from the second ground chain should be attached to the ring on the handle just below the ball, and a loop of the chain held in the operator's hand If the grounding is good, he will feel no effect from the current as applied to the patient, otherwise a light cramping of the wrist will be felt, in which case the grounding should be changed

It is essential to deliver to the patient but one spark at a time A shower of sparks on one area is unduly painful Skill in accomplishing this comes, of course with practice, but may quickly be attained if the ball electrode is moved rather rapidly through a semicircle When this is done, usually only a single spark will occur in that segment of the movement closest to the patient's skin One should pass by, rather than toward, the surface being treated A series of running sparks may be given by rapidly moving the electrode parallel to the surface of the patient's body and at the proper distance from it Here the sparks on different parts of the surface are not particularly painful Better to localize the spark, the loop shaped director, recommended by Snow, is most valuable In this case the semicircular movement may be described on the shoulder of the director several inches from the patient's body and the effect is exactly the same

It adds greatly to the comfort of the patient if the sparks are given in regular rhythm so that he is prepared for the slight shock which they produce Again it should be emphasized that all organized tissue exudates should be treated with some effective form of heat before using sparks Sparks are extremely unpleasant over bony prominences, and they should be avoided if possible The relief from pain experienced after application of sparks to congested tissue is in a large measure that of the relief of pressure on nerve endings Muscle spasm of many types, with its associated pain, is quickly relieved by sparks Joint

CHAPTER IX

PHOTOTHERAPY

HARRY EATON STEWART

LIGHT THERAPY IN GENERAL

History—The application of light in the treatment of disease is mentioned in the earliest medical writings extant It disappeared from medieval literature to reappear only shortly before the beginning of the last century Among the early writers the French took a prominent part About the middle of the nineteenth century we begin to find definite recommendations for the use of sunlight in tuberculosis, arthritis rickets and other conditions Toward the close of the century Finsen and Rollier added much to our knowledge of heliotherapy Recently, work of value has been done by T Howard Plank of Chicago Edgar Mayer, of Saranac Lake, Major Chris M Simpson of New York Virgil C Kinney of Wellsville New York A J Pacini of Chicago and others In attempting to simulate the healing power of the sun Finsen Arons and Cooper Hewitt did valuable research work

Physics—It is extremely difficult to divide phototherapy into convenient sections since sunlight radiant light and to some extent ultraviolet light overlap in both physics and physiological effects A brief consideration, however, of the entire range of light vibrations will form a foundation upon which a short discussion of these individual differences may be based

There are light vibrations, invisible to the eye but potent in their physical effects at both ends of the spectrum Below the visible light rays are the hertzian waves of extreme length up to several hundred feet with slow vibration rate These are the agencies concerned in wireless transmission Next we come to the infra red or burning rays which range from 900 down to 800 millimicrons in length and are quite penetrating and heating in their effects The visible spectrum ranging through red orange yellow green blue indigo and violet color extends from about 800 down to 400 millimicrons Next we enter the field of ultraviolet radiations Those contained in unfiltered sunlight extend down to about 300 milli

effect is that of the static wave and it has a somewhat general tonic effect It is easily applied to two parts at once such as the two knees or bilateral muscle groups The ordinary galvanic or high frequency electrodes may be used The terminals being first closed, and later opened to the required distance, the patient receives unidirectional condenser discharges It is not really a type of high frequency current, as has often been supposed

The Simple Charge—The use of the same machine "set" and technic as for effluve but without drawing off any of the current through the second ground chain, produces this type of current The patient, therefore, becomes highly charged, the current leaving his body by diffusion through the air This current is used to promote sleep and to raise blood pressure and for mild general tonic effects

The writer is aware of the supposed difficulties in the use of static electricity and that it has been hard to obtain simple concrete directions as to its use He has attempted to supply these The beginner in the use of static electricity will very quickly overcome his diffidence in handling the machine and become impressed with the results he is able to attain in properly selected cases

but merely toughens the skin, and that the greater therapeutic results obtained in all irradiation of those who tan are due largely to the increased absorption they possess to the light rays. Light penetrates easily to an inch and an eighth, some to an inch and a quarter, but in none of his many experiments did any light penetrate an inch and a half of human tissue. He calls attention to the fact that this degree of penetration is sufficient to reach the surfaces of the smaller joints, to pass through a thin abdominal wall, and that it will certainly reach sinuses, the middle ear, some of the mastoid cells and other locations where clinically light has proved to be therapeutically effective.

Absorption.—There can be no question that ultraviolet rays whether obtained from direct sunlight or quartz lamps, are absorbed by the blood stream and set up photochemical reactions throughout the body which have rather marked effects. The sensitization of cell protoplasm induced by the action of light vibrations on certain cells undoubtedly accounts for the lethal effect produced on bacteria. Sampson was able to affect a screened photographic film applied to one portion of the body after the exposure of another part to ultraviolet light. Many general effects resulting from exposure to the longer wave-lengths, typified by the red rays are merely those of heating the blood stream although an increase in certain blood elements has been thought by some investigators to be present. Similar increases in the red and white cell count, however have been found at high altitudes without exposure to the sun, also after irradiation with sunlight or artificial light through glass in which the ultraviolet rays were entirely lacking, like increases have been reported. Much work remains to be done before the exact effect of light on the circulation is made clear in detail.

Pigmentation.—This is to a certain extent a protective phenomenon on the part of the body evoked by all light but most intensely proved by the action of ultraviolet light on the skin. The nature and etiology of the process is not yet well understood.

With these few general considerations we will turn to the various types of light administration to the body and consider more in detail their differential effects.

HELIOTHERAPY

Sunlight contains a small percentage of red rays some 80 per cent yellow and green, 5 per cent blue and a small and quite variable percentage of ultraviolet. The ultraviolet rays are easily destroyed or made ineffective by moisture dust and organic matter in the air. They are greatest in amount in the noonday sunlight. They vary with the season of the year and in general come through in richer amounts in high clear

microns and the shorter wave lengths derived from mercury quartz lamps range down to about 190 Beyond that lies a field of vibrations as yet unexplored and unknown, then the alpha, beta and gamma emanations from radium and, finally, the X ray There is throughout this entire scale *a steady decrease in wave length and a corresponding increase* of rapidity of wave vibration rate It may, in general, be stated that the hertzian waves are the most penetrating, X ray and radium next, then visible light and, least of all, ultraviolet With the exception that most experiments on ultraviolet penetration are based upon vascular red tissue, recent experiments are modifying our idea of the apparently slight degree of penetrability with which they have been credited Many points in the physical effects of light are extremely involved and the writer is only attempting to describe the main effects in the simplest possible form.

Penetrability—Several investigators have claimed that red rays penetrate quite deeply into living tissue Yellow and blue rays penetrate somewhat less and ultraviolet ordinarily do not go far beyond the superficial layers of the skin Kinney and Shamberg have been able to effect photographic plates through the hand and through the cheek with ordinary incandescent light By far the most painstaking and accurate experiments in the penetration of light have been done by Virgil C Kinney and a thorough understanding of this subject is hardly possible without examining, at some length his results He built a lightproof box and with the use of carbonized putty was able while using it, both with the photographic film and the fluoroscope, to exclude completely all light not coming through the part under examination In using the body of a fish he found the usually believed order of penetration, greatest with red rays and least with ultraviolet, to be reversed and he concluded that there would be a uniform increase in penetrability from the red rays clear through to the X ray increasing in proportion to the rapidity of vibration, except that the blood acts as a red filter screen especially to handicap the ultraviolet band The conclusion has been confirmed by demonstrating the penetration of the ultraviolet rays with compression of the tissues, thus creating an anemic area in front of them Light does not penetrate directly in proportion to the candle power, although with the more powerful lights it is somewhat greater in degree than with weak lights Natural sunlight gives a greater amount of penetration than any artificial rays, except radium and X ray Of unusual interest are the results he obtained in the relative penetration of light through three hands from blond, brunette and negro which calipered to exactly the same thickness In both fluoroscopic and photographic tests the penetration was greatest in the negro less in the brunette and least in the blond individual The human retina can detect light rays coming through which do not fog any photographic plates at present obtainable He concludes that pigmentation is not a protective mechanism against light *penetration*,

much more than the light or auburn type The initial exposure is roughly four to ten times that of quartz light and should vary from twelve to thirty minutes with five to ten minutes daily increment in those patients whose tolerance is built up rapidly by training Another method of getting the patient accustomed to the treatment is to zone the body Expose the leg, then leg and thigh then the hips and so on until the entire body, front and back, has been exposed Maximum time may be extended to several hours with those who tan readily A cool sponge bath and brisk rubdown with a rough towel should follow all general treatments (for further details see article by Pryor)

Mirrors may be used to concentrate the light effect in a shorter space of time Direct exposure of the chest is avoided where there is any fever

Indications—Heliotherapy will be found most valuable in those localities where the sun is shining a large part of the time and where its rays are richest in ultraviolet light It is indicated in practically all forms of tuberculosis with the exceptions noted above, in rickets, anemia and certain slow healing wounds Certain investigators found that good results were being obtained in badly infected wounds in sections of South America, even in spite of lack of screening Mayer calls attention to the part the *air bath* plays in the healing process

Contra indications—There are a number of conditions which either absolutely contra indicate solar irradiation or modify very materially the *amount of dosage ordinarily given These conditions are*

Active pulmonary tuberculosis associated with fever

Hemophilia and hemoptysis

Valvular heart lesions of any marked degree

Marked general nervous condition

Albuminuria to any considerable amount

Skins extremely sensitive to light show a solar eczema or Hutchinson's prurigo

RADIANT LIGHT

Definition—Radiant light consists largely of the luminous rays from the arc, carbon tungsten or nitrogen filament lamp This light as generated by the electric current, contains some of the intra red rays and all of the wave-lengths of the spectrum Since the filament lamps are always *enclosed* in glass bulbs we may assume that no *ultraviolet* rays pass through the glass and reach the patient The color of the glass has probably but slight influence upon the therapeutic effect of the light The rays transmitted through red glass are slightly more irritating and burning while those through blue glass are less irritating and slightly analgesic This selective effect of color, however is greatly exaggerated in the claims made for certain lamps

mountain air *It should be constantly kept in mind that the shorter rays will not penetrate glass or the thinnest cotton or silk cloth*

Physiological Effects—As would be expected, physiologic l effects vary somewhat with the varying ultraviolet content in the sunlight The *local effect upon the skin varies with the dosage* Laroquete has clearly described the effect of the solar rays on the skin as follows When the exposure is mild in type and of short duration, there is produced a mild erythema which disappears after the exposure If the duration is sufficient, this primary erythema remains and is due to the effect of the heat rays, similar in effect to those from hot air or other thermal sources In longer and stronger exposures the epidermis is affected by the light rays, especially by the more rapidly vibrating ultraviolet band, producing slight capillary extravasation of blood under the skin and followed by pigmentation, varying with the intensity of the exposure Still longer exposure results in a real dermatitis of painful type with exudation and exfoliation Prolonged exposure gives a typical first degree burn with necrosis of the epithelium, congestion and dilatation of the blood vessels, hemolysis, edema and extravasation of blood pigment into the tissues Repeated exposures of moderate duration, superimposing one burn on another may produce an accumulative burn of considerable severity or the skin may become pigmented and immune from further burning The general systemic effects of properly graded doses are, as a rule, an increasing hemoglobin percentage The erythrocytes often show a steady increase An immediate leukopenia is followed by a leukocytosis and gradual return to normal There is a general increase in all the assimilative and eliminative processes of the body Some of this general tonic effect must, undoubtedly, be attributed to the associated fresh air which patients under this type of treatment receive

Technic—With properly constructed wind breaks, patients may be treated through a large part of the year even in a climate as severe as New England, providing they become hardened to it during the milder months Special caution to prevent chilling is necessary at first The head should be protected by a small screen The treatments, to be efficacious, require that practically the entire body be exposed to the direct rays of the sun Leonard Woolsey Bacon, in his treatment of tuberculous ex service men, has devised an inexpensive arrangement easily built on any hospital roof or porch It consists of two long cross beams notched in pairs throughout their entire length to hold the handles of the ordinary army litter with a circular head screen of wire covered with ordinary muslin which fits into the head beam The portability compactness and cheapness of such an arrangement should allow for the treatment of many patients at the same time, with the expenditure of very little money or effort The initial exposure and amount of daily increment must depend upon the patient's tolerance to the sun The dark complexioned tand

rays, ultraviolet light as before stated not being present Spasticity of superficial muscles may be greatly relieved

General Effects—These are due to the liberation of heat and mild stimulation of the sympathetic nervous system increasing slightly all the metabolic processes of the body The relief of deep-seated pain has been repeatedly demonstrated clinically but a satisfactory scientific explanation of it has yet to be evolved The claims made for the effect of luminous rays upon the blood count are varied and for the present must be discounted

Apparatus—A wide variety of radiant light apparatus is at present on the market varying from small portable 100-candle power lamps with reflectors to 2,000-candle power lamps on adjustable stands For home use the smaller lamps are quite efficient but for extensive clinic hospital or office practice the larger lamps are to be preferred There are also available a number of types of apparatus containing from two to sixteen small carbon bulb adjustable in various ways, to place over a certain part of the body Some of them are well built with switches controlling a given number of lights but they have been largely superseded by the use of the more powerful single bulbs It is important that the reflector should be so arranged that the light will be properly focused on the patient s skin a given distance from the lamp usually twelve to eighteen inches If this focal distance is maintained there is economy in the use of the lamp For general body treatment a large variety of bath cabinets have been manufactured both with and without reflectors and ventilation The number of lights in these cabinets varies from forty to one hundred The reflectors used should be so arranged that the rays do not overlap There is probably no particular advantage in having such a cabinet ventilated during treatment Those cabinets in which the patient is placed in a horizontal position are to be preferred to other types

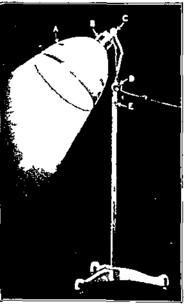

FIG 2 —THE 1 500 CANDLE POWER RADIANT LAMP WITH STAND

Carbon Arc Light—This type of light is not glass covered and contains a certain proportion of ultraviolet rays It has been developed by Finsen in the Copenhagen Institute Flying particles of carbon prevent the treatment of patients directly under the light. Four telescopic tubes

Therapeutic Effect—There can be no question of the fact that luminous rays penetrate to a depth of nearly one and one-half inches through ordinary tissue and some writers claim far greater penetrative power Almost all of the radiant energy is undoubtedly changed to heat in the tissue, and this heat is liberated as deeply as the rays penetrate Turrell states that in clinical practice he detects little or no difference between the effects of radiant heat administered by light baths and the effect of the convective heat of the hot air bath, or conducted heat by means of the direct application of other substances to the skin He states that the convenience of the electric light as a mode of application is all that it has to commend it above the other methods It is doubtful whether any other form of heat except diathermy penetrates actively vascular tissue to the depth of radiant light The qualitative effect of light upon the skin and sensory nerve endings is probably definite and greater in the case of the radiant energies Other writers, notably Kinney and Snow, state that the effects produced upon metabolism cannot be explained on the basis of the heat production alone

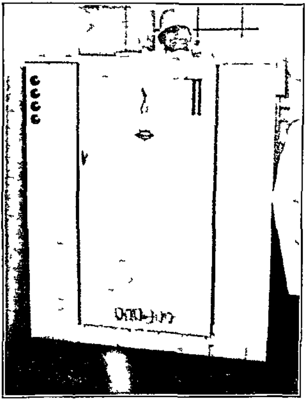

FIG 1—BODY RADIANT LIGHT BATH CABINET

Local Effects—These are mainly the intense stimulation of the skin and skin glands consequent upon the marked degree of hyperemia induced in the skin and subcutaneous tissue to the depth of the light penetration The analgesic effect of light is very marked and constitutes one of its main therapeutic indications. This effect too, is produced in proportion to the amount of heat developed Its bactericidal effect, especially on anaerobes, is great though this effect is less marked than with ultra violet irradiation A slight local pigmentation of the skin follows repeated exposure to radiant light and is probably due to the blue and violet

in saying that, in general, radiant light is more effective and has none of the disadvantages of many of the forms of external heat application still so commonly used

Contra indications—There are no real contra indications for the use of radiant light except where its prolonged use might delay the application of the properly indicated surgical medical or other physiotherapeutic measures For this reason, if for no other it belongs together with all other potent physical agencies, in the hands of the physician

ULTRAVIOLET QUARTZ OR ACTINIC RAYS

Definition—Ultraviolet rays are the invisible light vibrations, between 400 and 100 millimicrons in length

History—In 1892 Arons was able to electrify mercury vapor and produce a light entirely lacking in orange and red rays Some years later, Cooper Hewitt perfected such a lamp in a glass vacuum tube Heraeus Kromayer and Nagelschmidt were collectively responsible for the perfection of the quartz burner and the employment of this lamp in therapeutics The perfection of the tungsten mercury burner and improved methods of fusing quartz making possible applicators with various curves and angles and portable water-cooled lamps, are recent developments of great value

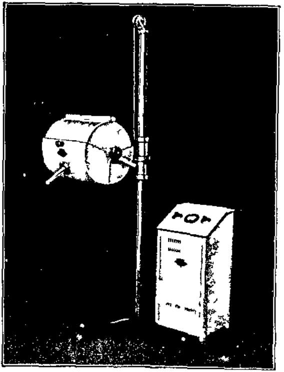

FIG 3—MERCURY TUNGSTEN AIR COOLED ULTRAVIOLET LAMP WITH RECTIFIER AND LOCAL APPLICATOR

Physics and Physiological Effects—Sunlight contains the longer ultraviolet wave-lengths those down to about 00 millimicrons the therapeutic effect of which has been already considered in connection with

are used to convey the light to patients around the lamp Its effect rather closely resembles that of sunlight Since the apparatus is expensive and cumbersome, its use is decreasing and no further space will be taken up with the special technic involved The writings of Mayer, Finsen, Hess and others are recommended to those who desire detailed knowledge regarding the use of this type of lamp

Technic —The type of lamp selected will naturally depend largely upon the indications presented The 1,500 or 2,000 candle-power single bulb has several advantages The patient may shift his position, both as regards distance and direction, without the help of the operator No satisfactory general elimination, however, may be secured with the use of this type The body cabinet bath alone will do this work properly The distance should be determined by the skin tolerance to the candle power used The time of the treatment depends not only on the indication but upon whether or not other types of heat, such as paraffin bath, surface high frequency or diathermy, are to be used in conjunction with radiant light Where the entire heat effect is to be derived from radiant light, from twenty to forty minutes is the rule, otherwise, as short a time as ten minutes may suffice In the body cabinet bath it is well to keep the head constantly covered in a towel dampened with cold water and to terminate the treatment immediately when there is undue rise of temperature or pulse, or soon after profuse perspiration has developed. Twelve to twenty minutes should constitute the average treatment Some mild tonic type of hydrotherapy or a rest period is advisable before the patient is allowed to go outdoors

Therapeutic Indications —Radiant light is used as a preliminary measure to massage and other forms of physiotherapy To relieve pain in a wide variety of conditions it has no equal in efficiency and ease of application It is to be preferred to the old fashioned poultice or its modern prototype in cases of local infection, preceding incision or the application of ultraviolet or X ray It is used to bring about surface hyperemia for greater systemic effect by absorbed ultraviolet rays, in practically all general treatments from air cooled quartz lamps There are a few indications of special value which should be mentioned separately In acutely inflamed joints where other physiotherapeutic measures can not be borne, radiant light may be used for hours for its analgesic effect In congestive pain in the middle ear or sinuses prolonged treatment by light has proved very efficacious In the relief of erythema solare, from prolonged sun or ultraviolet exposure it has given good results Pain following operative incision may be safely conveniently and to a very large extent relieved, by prolonged and distant radiant light application The general indications for the use of radiant light as given are so many, it is so easy and convenient to apply and so therapeutically effective that it is certain to receive increasing attention and use I have no hesitation

in saying that, in general, radiant light is more effective and has none of the disadvantages of many of the forms of external heat application still so commonly used

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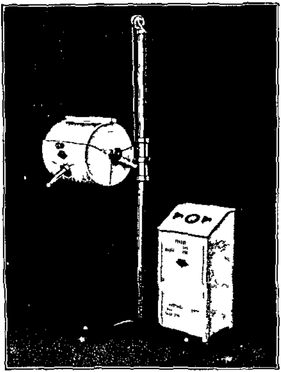

FIG 3 —MERCURY TUNGSTEN AIR COOLED ULTRAVIOLET LAMP WITH RECTIFIER AND LOCAL APPLICATOR

Physics and Physiological Effects —Sunlight contains the longer ultraviolet wave-lengths those down to about 300 millimicrons the therapeutic effect of which has been already considered in connection with

heliotherapy The mercury vapor quartz light contains these longer rays and, in addition, is rich in the shorter, more chemically active wave-lengths, running down to about 190 millimicrons The still shorter vibration lengths are not yet available for therapeutic purposes The proportion of ultraviolet rays in the common types of light have been tabulated as follows

ULTRAVIOLET RAYS IN THE COMMON TYPES OF LIGHT

Type	Per Cent Infrared	Per Cent Luminous	Per Cent Ultraviolet
Mercury Vapor	52	20	28
Sunlight	80	13	7
Carbon Arc Lamps	85	10	5
Incandescent Lamps	93	6	1

Penetration —Ultraviolet rays, even in pure quality from an air cooled lamp, only penetrate a very short distance, because of the red filter screen action of the hemoglobin before mentioned Under compression from surface quartz applicators or other means, the depth of penetration is very much greater, probably one-half to one inch according to the completeness with which the tissue is made anemic It must be recalled that these actinic rays will not pass through glass, paper, thin cloth or ointment but will pass quite readily through sterile water

Variation —There are certain fundamental differences between the quality of lights which *emanate from the water-cooled* and the air-cooled burners The radiations from the air cooled lamp are predominantly the longer ultraviolet wave-lengths They are more penetrating, are absorbed in larger amounts and stimulate metabolic processes

From the water cooled burner we get a larger proportion of the short or far ultraviolet wave lengths It is this band that is most actively germicidal The penetrative power of these wave-lengths is not as great and they are not as stimulating to metabolism

With the use of either type of lamp there are certain factors which cause the expected result to vary

The dust moisture and organic material in the air, which at times so markedly reduce the ultraviolet content of sunlight may in like manner effect to some extent the quantity of ultraviolet irradiation the patient receives from the lamps A more important factor is the variation in and the amount of electrical current A comparatively slight *change in electrical strength may result in rather wide variations* in ultraviolet output amounting at times to as much as 15 or 20 per cent

Local Effects —These vary according to the make and type of lamp used, time, distance, and individual susceptibility of the skin to these rays Ordinarily, no heat is felt and no perspiration induced The skin may

react all the way from the faintest erythema to a complete first degree burn The latter is, however, the most severe local effect it is possible to obtain and is insignificant in comparison to overdosage by X ray or radium applications

In moderately severe doses the following histological changes in the skin have been found There is dilatation of both the superficial and deep skin capillaries The epidermis may loosen and blister The nuclei of the skin cells show division and the lymph spaces become dilated In mild doses there is only a moderate dilatation of the capillaries The erythema does not appear for several hours after the treatment thereby differing from the heat erythema which appears immediately Pigmentation of the skin usually begins on the second or third day is steadily increased by repeated doses and protects the skin from further erythema or blistering The exact effect of the rays on cellular activity is not definitely known The shorter wave-lengths are those which produce most marked changes in cell protoplasm This is especially true of their effect on microorganisms Bovie found that the paramecium when exposed to sublethal doses of ultraviolet rays, became so sensitized to heat that they were unable to withstand for a full minute a degree of temperature which was optimum for controls He concluded that death was due to heat coagulation after sensitization by the light Other investigators have found cell protein to be less soluble and more easily precipitated after exposure to light Finsen confirmed the bactericidal action of actinic rays in his work with lupus Bacteria have been killed at a depth of 1½ millimeters and their virulence markedly diminished at a depth of 4 millimeters The tubercle bacillus loses its staining properties very quickly when exposed to ultraviolet rays and is killed in a short time

The skin dosage is roughly classified as stimulative (mild), regenerative (medium) and destructive (severe) erythema

General Effects—It is extremely difficult to give a clear-cut and conservative estimate of the general effects of ultraviolet light upon the body We are eager to have our clinical results confirmed by exact scientific demonstrations but unfortunately there is not as yet, entire unanimity of opinion among those who have investigated this subject It is in general, found that there is an increase in the percentage of hemoglobin and in the erythrocyte count a temporary drop in the number of white cells, followed by a fairly permanent increase and a building up of the resistant forces of the body toward all types of infection This is the usual result reported also in the clinical use of general ultraviolet treatments

There is often a relief from pain out of proportion to the minute amount of heat produced and to the possible counterirritant effect of the erythema resulting This may be due to a selective action on sensory nerve endings As a rule patients sleep better after properly selected

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Local Effects —These vary according to the make and type of lamp used, time, distance, and individual susceptibility of the skin to these rays Ordinarily, no heat is felt and no perspiration induced The skin may

dosage There is usually some fall in systolic blood pressure The effect of rays absorbed in the blood stream is of course diffused throughout the body General metabolism and especially elimination seem to be augmented after general treatments Again let it be understood that while these results are fairly constant and may in the majority of cases be expected under proper technic they are still somewhat empirically employed The work of A F Hess of New York Janet H Clark and others on the subject of rickets has clearly demonstrated the effect of ultraviolet light on blood chemistry A marked increase in the inorganic phosphorus followed by rapid calcification of bone was shown after exposure to the ultraviolet light in cases of rickets in both animals and children The results obtained by general irradiation in tuberculosis must be effected by means of rays absorbed and distributed by the circulation

Apparatus—*Lamps*—We have available air cooled lamps for general radiation and water-cooled lamps for local work, each provided with rectifiers for the alternating current There are many varieties of stands methods of counterweighting, ease adjustment and other conveniences for the clinician's use Convenience appearance durability, power, etc, have each to be considered in choosing a given type of lamp

Burners—The burner is the important part of the lamp Some valuable information regarding burners has been furnished by W W Coblentz, of the Bureau of Standards There are two types of burners on the American market one consisting of a vacuum arc in a fused quartz chamber the arc discharge taking place between electrodes of liquid mercury—the all mercury burner the other type has metal lead in wires, sealed directly to the quartz burner Within the burner the cathode is liquid mercury and the anode is a flat coil of tungsten wire which is at a low red incandescence when the burner is in operation With tests made at about 300 watts there seemed to be no difference in ultraviolet output either in quantity or quality It is possible that a difference would have been found with the use of heavier wattage With the use of the 110 volt current, the intensity varied inversely as the square of the distance, while with the 220 volt current this variation was somewhat greater than the square of the distance inversely

The greatest intensity is received on a surface parallel to the long axis of the burner and the oblique rays are noticeably less efficient Small variations in the light voltage greatly change ultraviolet output Burners having A C current operating through rectifiers last longer than those operated on D C Burners deteriorate steadily with use This may be due to the ionized incandescent mercury vapor attacking and combining with the quartz forming dark deposits which may become porous and admit minute amounts of air which combine with the mercury Burners deteriorate from one half to one-third after some fifteen hundred to two thousand burning hours As a rule, the lamp on a stand with

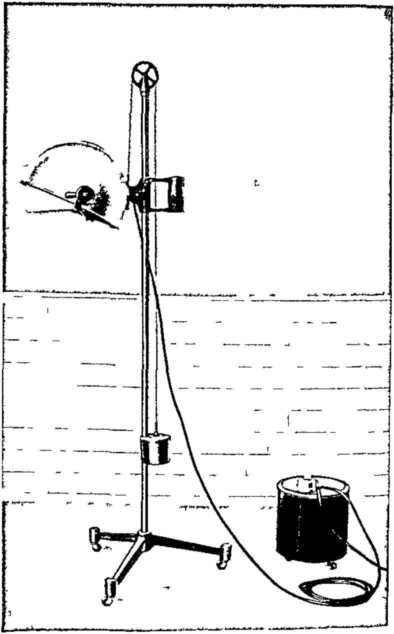

FIG 4.—THE ALL MERCURY AIR COOLED ULTRAVIOLET LAMP WITH RECTIFIER AND COUNTER WEIGHT

castors is more convenient than one counterweighted from the ceiling The manufacture of burners is a difficult and highly specialized task which makes them rather expensive They have to be able to withstand a temperature of 3,700° F

Applicators—For general needs one large square applicator, a medium circular and a small circular applicator should suffice for surface work They are also made curved to different degrees and will conveniently reach all parts of the gums for dental work A nasal, tonsillar, vaginal and rectal applicator will complete the number absolutely necessary for cavity work It is desirable in addition to have at least one small sinus applicator New methods have made it possible to fuse quartz in such a manner that the rays are emitted in nearly full strength from the end of curved applicators The rooms in which actinic rays are used must be frequently ventilated

The eyes of both the operator and patient must be protected from the ultraviolet rays, for they tend to set up a conjunctivitis The manufacturers provide glasses which are opaque to actinic rays, and they should be constantly worn A little carelessness in this regard after some familiarity with the lamp is common and almost always results seriously

Care of Apparatus—After the rectifier switch is turned on, the lamp is started by tilting the burner so that the mercury flows to the tungsten anode, forming a contact The effect of this contact is temporarily to short-circuit the current and this is the point where the greatest drain on the current supply occurs For this reason every circuit into which the ultraviolet apparatus is to be plugged should be heavily fused at least to 30 amperes When the lamp is tilted back to its former position, the current continues to pass through the vaporized mercury which until thoroughly heated has a high resistance to the current It will be noted that the voltmeter registers only a small amount of current flowing As the mercury vapor becomes intensively heated, the voltmeter reading increases and the light emitted by the burner becomes more intense Hence in all types of lamps a preliminary burning time of from five to twelve minutes is necessary before a full quantity of ultraviolet rays are produced and this refers particularly to the shorter and more potent wave lengths The burner should never be touched with the hands but lifted or tilted if necessary by the metal shoulder Clean the burner off daily with alcohol With the use of the water-cooled lamp, it must be made certain that a free flow of water is circulating in the lamp before it is turned on If this is not done the burner will be destroyed in a very short time For this rea on it is safest so to arrange the water intake that either the inflow or the outflow is visible to the operator It is well also, to allow the water to run for a moment or two after the lamp has been turned off One quick lateral or posterior tilting of the lamp is usually all that is necessary to ignite the mercury after the cur

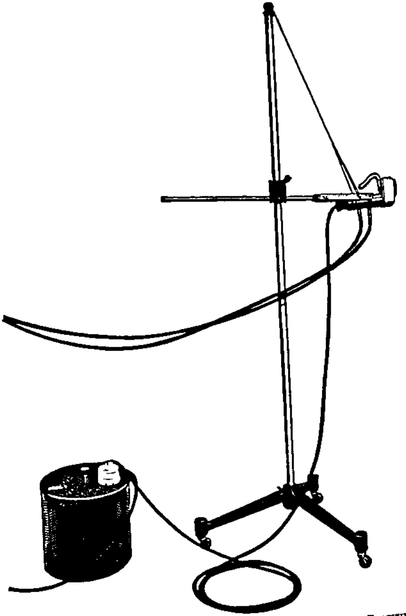

Fig 5.—Standard of the Water cooled Ultraviolet Lamp with Rectifier.

the average initial dose, we have three variations of intensity mild, medium and severe In addition there are three different skin doses, namely, stimulative, regenerative and destructive any one of which it may be our aim to produce

A *stimulative* erythema is the creation of a faint blush after a short treatment at average distance This produces superficial capillary engorgement, stimulates surface epithelium and is the degree used for most general treatments

The *regenerative* dose induces a deeper redness just short of blistering It is destructive to surface cells is stimulating to deeper lying cells and produces marked capillary engorgement with considerable absorption of rays This dosage is used in most widespread inflammatory skin diseases and for cavity work

The *destructive* dose induces blistering and vesication of superficial layers of cells, entirely destroying them, but the deeper layers of the skin are markedly stimulated to multiplication and growth Its use in infective and hypertrophic skin lesions gives us the desired sharp, intense, localized result

To provide a technic by means of which we may accurately grade the dose in its proper relation to susceptibility, the manufacturers have provided a method for determining the lamp output It consists of small pieces of sensitized paper which are exposed for fifteen seconds at a standard distance and developed in water dried and compared to a varying scale of blue, much as hemoglobin is commonly tested on a Tallqvist scale Opposite each sheet of color the number of seconds required to produce a mild erythema in the normal skin is given

We then test the patient's skin with a dermographic pencil to determine its reaction A white line appearing immediately after the scratch is *normal* no result *negative* and a red line *active* The person showing a white after line requires the average dose When no reaction follows increased dosage is required while the red line indicates a skin which will burn easily This skin reaction may vary in the same patient at different times

In the treatment of the average adult patient for general effect an abbreviated schedule of time and distance for different grades of susceptibility with either type of lamp should prove useful and is appended

ALL MERCURY BURNER

(Initial distance 18 inches)

Skin Reaction	Time	Daily Increment Seconds
Negative	4 minutes	40
Average	3	30
Active	2	15

rent is turned on. Once lighted, it should always be allowed to come up to maximum before starting treatment During the treatment, the lamp should not be tilted to more than twenty degrees from the vertical plane This deviation may, at times, be carried to forty degrees, but it is safer to adjust the patient's position and attempt to maintain the lesser degree of tilting just mentioned

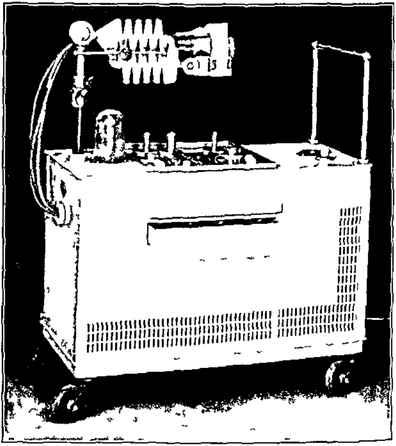

FIG 6—NEW TYPE PORTABLE WATER COOLED ULTRAVIOLET LAMP FOR WARD WORK.

Technic—*Air cooled Lamp*—The problem of accurately measured dosage in actinotherapy is a complicated one Slow diminution of effect, due to prolonged usage of the burner, must be considered The variations of atmospheric conditions and current strength modify the results obtained Patients differ quite markedly in their skin reaction to the quartz light. There are a few persons, extremely susceptible, who have toward the rays an idiosyncrasy comparable to that exhibited by some toward certain drugs These patients develop an intense eczema which is difficult to allay Within the range of what might be termed normal reactions to

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The *regenerative* dose induces a deeper redness just short of blistering It is destructive to surface cells, is stimulating to deeper lying cells and produces marked capillary engorgement with considerable absorption of rays This dosage is used in most widespread inflammatory skin diseases and for cavity work

The *destructive* dose induces blistering and vesication of superficial layers of cells entirely destroying them but the deeper layers of the skin are markedly stimulated to multiplication and growth Its use in infective and hypertrophic skin lesions gives us the desired sharp, intense, localized result

To provide a technic by means of which we may accurately grade the dose in its proper relation to susceptibility the manufacturers have provided a method for determining the lamp output It consists of small pieces of sensitized paper which are exposed for fifteen seconds at a standard distance and developed in water, dried and compared to a varying scale of blue, much as hemoglobin is commonly tested on a Tallqvist scale Opposite each sheet of color the number of seconds required to produce a mild erythema in the normal skin is given

We then test the patient's skin with a dermographic pencil to determine its reaction A white line appearing immediately after the scratch is *normal* no result *negative* and a red line *active* The person showing a white after line requires the average dose When no reaction follows, increased dosage is required, while the red line indicates a skin which will burn easily This skin reaction may vary in the same patient at different times

In the treatment of the average adult patient for general effect, an abbreviated schedule of time and distance for different grades of susceptibility with either type of lamp should prove useful and is appended

ALL MERCURY BURNER

(Initial distance 18 inches)

Skin Reaction	Time	Daily Increment Seconds
Negative	4 minutes	40
Average	3 "	30
Active	2	15

Tungsten Mercury Burner

(Initial distance 30 inches)

Skin Reaction	Time	Daily Increment in Seconds
Negative	1½ minutes	20
Average	1¼ "	15
Active	50 seconds	10

The different regions of the body vary in their sensitivity to ultra violet light. The front of the arms burn somewhat less readily than chest and abdomen. The back of the arms and legs require twice the average dose to produce an erythema. The back of the hands withstand several times the usual amount, while the palms and soles of the feet are very difficult to burn.

Age has some relationship to skin sensitivity to the light. Infants require one-fourth, children one third and the aged two thirds of the average initial dose and daily increment.

Females react to an exposure some 20 per cent less in time than that required to produce the desired degree of reaction in males. Blond types in both sexes are more susceptible than brunettes.

It is not generally necessary to use any intensifying devices. Desired intensification may be easily secured by lessening the distance, without the added wear and tear on the burner of the lamp. If an intensifier is used, it should never be applied until after ten or fifteen minutes of burning time.

We have considered so far the problem of initial dosage. There remains to be discussed the problem of daily increment. This may be accomplished by increasing the time of the exposure, lessening the distance from the burner to the patient or by a combination of these two methods. Minor increases are better regulated by increasing slowly the time of exposure.

The aim in most general treatments is to produce the mild erythema dose and increase the exposure as rapidly as tanning will permit. We, therefore, divide the body into two or four zones which are rayed successively. In this manner the unpleasant features of erythema have largely disappeared before that particular surface is again treated, and tanning is slowly developed with a minimum of discomfort or peeling. It is well, even when attempting merely this mild reaction, to explain to the patient that there may occur a real sunburn, because, in spite of all possible precautions, unexpectedly severe reactions occasionally occur and it is safer to have the patient mentally prepared for such an occurrence. In those who burn but do not tan, the dose is naturally much reduced and the daily increase very slight. Where smaller areas than a

full body zone are under treatment for more or less local effect and it is necessary to push the treatment, one burn may be superimposed on another with no danger other than the superficial skin destruction already described The average daily time increase bears of course, a general relationship to the time of the initial dose, ranging from 10 to 25 per cent of it No increase at all may be possible in those who do not tan It should be remembered that a lapse of several days during the treatment especially if accompanied with peeling, will necessitate the return to pretty nearly the initial dose In any prolonged general treatment it is well to drop back to almost the beginning dose and again work up after a maximum of twenty to thirty minutes exposure has been reached and maintained for a short time This is comparable to the giving of certain drugs in courses Various unpleasant sensations are noted in patients who have been continued at general maximum treatment for a considerable length of time

In certain conditions noticeably those of or complicated by pulmonary tuberculosis both the zoning and the daily increase must be much more carefully worked out In some conditions and tuberculosis is a noticeable example of them, even the average initial dose of ultraviolet light may be followed by a rise in temperature Most of those who have worked with the lamp in these conditions feel that this is not a necessarily dangerous or unfavorable reaction but comparable to that following tuberculin or the use of certain vaccines However since a temperature rise of this type is the cause of a perfectly natural alarm on the part of workers not familiar with the use of the lamp and since we must be very guarded in pushing any new treatment especially in active pulmonary cases an effort should be made so carefully and gradually to grade the dosage as to ultimately attain the desired results without any undue rise of temperature Such a plan has been worked out and put in operation in our Service in the United States Veterans Tuberculosis Hospital at New Haven by Major Leonard Woolsey Bacon and is described in detail in the section on Applied Physiotherapy relating to Tuberculosis.

Water cooled Lamp—This is used only on small areas for very intensive effect It is the bactericidal effect of the short wave-lengths that usually recommends its use For regenerative effect treatment may be given through the quartz window at a distance of one or two inches from the skin, using exposures varying from thirty seconds to two minutes For most surface work the quartz applicators mentioned are used They should be carefully cleaned with alcohol before and after each treatment All crusts, scabs, ointments and other foreign substances should be removed from the affected area before commencing treatment Gentle firm pressure is used directed at right angles to the surface The surrounding area of skin may be protected by zinc oxide plaster, ointment towels or heavy black photographic paper The time of exposure varies from

thirty seconds to twenty or thirty minutes, depending upon the effect that it is desired to produce. In cavity work with the various special applicators, one to two minutes is generally employed. Gentle, firm compression is also used on the gums, and one or two minutes with slight daily increase is the average time of the treatment.

Pacini gives the exposure time required to kill various bacteria suspended in clear sterile water at 200 millimeters as follows:

	Seconds required to kill
Diplococci	
Gonococci	6
Meningococci	6
Staphylococci	
Pyogenes albus	10
Pyogenes aureus	12
Streptococci	
Viridans	14
Hemolyticus	18
Mucosus	25
Pneumococci	
Group I	25
Group II	20
Group III	[illegible]
Group IV	15
Bacilli	
Influenza	18
Diphtheria	10
Tubercle	12
Lepra	1
Colon	18
Typhoid	18
Dysentery types	20

Treatment Precautions.—It is well to summarize a few of the important points demanded by proper technic. Burn the air-cooled lamp not less than six minutes before starting treatment. Place the lamp so that the surface to be treated is well centered and parallel to the long axis of the burner. If applicators are used on the air-cooled light, as occasionally convenient, adjust the patient to the lamp and nearly double the time you would use with the water-cooled apparatus. After turning on the rectifier switch, see that the meter needle has moved on to the scale and not below zero. If the latter has occurred, reverse the wall plug before turning on the lamp. If the lamp has just been used and turned off, allow the burner to cool somewhat before attempting to relight it, after which it need burn only a moment or two to reach its maximum intensity. With the water-cooled lamp, be absolutely certain that the water is freely circulating before the lamp is turned on and, if possible,

do not tilt it more than twenty degrees during treatment Treat sunburns similarly to any mild first degree burn with radiant light at a distance

Therapeutic Indications —One hesitates to name all the indications for the use of ultraviolet light, lest it be thought that he is advocating a cure-all but the indications of proved value are many and include

Practically all local skin infections and simple alopecia
Sluggishly healing wounds
Burns of all types including those from X ray and radium.
Chronic ulcers of the skin and mucous membrane
Sinuses of all types where the area drained has been cleaned up
Deep seated infections, such as osteomyelitis, tuberculous empyema, adenitis, arthritis, and peritonitis sinusitis pyorrhea, alveolar abscess, superficial tonsillar infection the simple anemias and reduced hemoglobin

Pacini, in his text has worked out in detail the hypersensitive skin areas occasionally encountered in organic and functional disturbances of the various organs and claims results from regenerative doses of ultra violet light to these areas The writer would refer those who desire to go more deeply into the possibility of inhibiting reflex pain to Pacini s text

Contra indications —Ultraviolet light is usually contra indicated in patients with extremely sensitive skins, in those with hemophilia and active febrile tuberculosis in the last named at least as regards chest exposure

In the use of all types of phototherapy particularly ultraviolet light both natural and artificial we are employing a method of therapy faith in which is deeply implanted in all conscious living things Artificial production and refinements in technic have increased its availability and the potency of its application Its wider use in therapeutics is certain to bring most gratifying results The caution should be ever kept in mind that necessary surgery or supplementary hygiene and medication should never be postponed or omitted in connection with its employment in therapeutics

CHAPTER X

THERMOTHERAPY

William Benham Snow

History.—Heat therapy or thermotherapy has, from the earliest rec[illegible] been [illegible] in medicine. The old method of practice with [illegible] poultices [illegible] water bags, hydrotherapy, electric pads and [illegible] avail as compared with the modern methods of [illegible] therapy [illegible] the blood-stream carrying away the [illegible] rectum.

The [illegible] radiant energy and diathermy have [illegible] thermotherapy. There are various points with [illegible] which [illegible] have arisen and there are [illegible] of them. The following quota[illegible]

[illegible] the fact that radiant energy produces heat [illegible] to whether the term *radiant heat* [illegible] and the Encyclopedia Britannica [illegible] and also the application of the term [illegible] to the carrying away of heat by the blood [illegible]

[illegible] to be caused by an indestructible, [illegible] It is now known to be not a substance but the [illegible] consisting in the case of a gas of nearly [illegible] with sudden changes of direction and velocity [illegible] near enough to one another in the case of a [illegible] of its molecules and in the case of a [illegible] This motion entirely ceases only [illegible] The temperature is in fact nothing but the amount of heat per molecule.

"When heat was believed to be a substance the radiation of heat was [illegible] in the manner analogous to the abandoned emission theory [illegible] as the actual transfer of the heat fluid itself now however radiant

heat is known to be the energy of heat transferred to the luminiferous ether which fills all space and also pervades all bodies The hot body sets the other particles in vibration and this vibratory motion, in the form of waves, travels in all directions with a velocity of about 186 000 miles per second If this radiant heat impinges upon a body, part of it may be absorbed or, in other words the molecules of the body may themselves be set in motion by the ether waves There is no essential difference between radiant heat and light both being forms of radiant energy, the ether waves differing intrinsically among themselves in wave length only, and thus producing different effects, heating luminous and chemical, in bodies upon which they impinge, according to the nature of these bodies

'The rays whose heating effects are generally the greatest are of greater wave length than those which most affect the eye (light rays) and have longer periods of vibration Like light rays, they may be reflected refracted diffracted and polarized The quantity of heat of a body or the amount of heat energy which a body gains or loses in passing through a given range of temperature is measured in thermal units—heat units—that is by the quantity of water which it would raise through one degree Fahrenheit, it is given by the product of its weight into the number expressing the range in temperature multiplied by the specific heat. In ordinary speech *heat* and *temperature* are not distinguished' [1]

Since heat can be produced it cannot be a substance and since whenever mechanical energy is lost by friction there is a production of heat we conclude that heat is a form of energy"

'In the strictest modern scientific language heat is used to denote something communicable from one body or piece of matter to another'

Light That which makes things visible in *physics* it is that form of energy which acting upon the organs of sight renders visible the objects from which it proceeds

'The principal phenomena of light are grouped under the following heads (1) Absorption or the transformation of the vibration of the ether into the molecular vibrations of the body upon which the light falls or through which it passes The effect of the absorption of part of the light rays by a body is to give it color thus grass is green because it sends back to the eye only the rays which together produce the effect of green the other rays being absorbed and a piece of red glass owes its color to the fact that it transmits only that part of the light whose combined effect upon the eye is that of red.' [2]

Century Dictionary—Heat
Century Dictionary—Light.

FORMS OF HEAT

Three forms of heat, or methods of action of heat, are to be considered as applied to heat therapy—*conductive, convective* and *conversive*.

Conductive Heat.—Conductive heat, in living creatures, is the transmission of heat through the tissues of the body, and is limited to the skin, because *the circulating blood carries all excess, limiting penetration.* All methods by which heated objects are applied directly to the surface or interior of the body are, therefore, very limited in their effects upon the tissues underlying the integument.

Conductive heat is the least effective method of heat administration, *the heat being carried away by convection whenever applied externally* or internally to the skin or mucous surfaces. The parts exposed are promptly rendered hyperemic and the circulating blood conveys the heat *on to the general circulation, to be replaced by blood flowing into the* dilated blood vessels at the normal body temperature. Thus the excess heat passes on by *convection* and the tissues beneath the skin remain at about normal, rendering of little therapeutic significance applications such as hot water bottles, poultices, douches, baths, hot packs, wet dressings or electrically heated pads at temperatures that the skin will tolerate. Skin toleration to administrations of dry hot air at temperatures of from 400° F to 500° F. is possible if the surface is protected by an absorbent, such as Turkish toweling, which will absorb the collecting moisture of perspiration, otherwise liable to boil and blister the skin. If it were not for this convection through the medium of the circulating blood, such applications would be impossible and conduction would occur as it does in the roasting of a dead animal.

That there are undoubted benefits derived from external administrations of heat, even though convection carries away the excess, is conceded, and its therapeutic indications and significance will be considered later.

Convective Heat.—Convective heat is conveyed from the surface, the rectum, bladder or vagina by the circulatory channels—arterial, venous and lymphatic, in all of which the currents are accelerated—to be dispersed throughout the organism and eliminated by the natural channels of dissipation. The writer was the first to recognize the importance of the distinction between the therapeutic effects of external applications of heat and heat derived from radiant sources and believes that the first reference in medical literature [3] to the different effects was made by him in 1903. The following year Dr. J. H. Kellogg of Battle Creek published a small volume entitled *Radiant Light and Heat and Convective Heat*.

In all methods of heat administration, conductive, convective, or conversive, heat is dispersed by convection, for which reason it is necessary in

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[3] Radiant Light and Heat and Convective Heat, page 93.

the many important therapeutic indications with heat therapy to prolong the administrations as will be shown

Conversive Heat—This is the heat produced in a body by the transformation of energy, that is by conversion of radiant energy, electrical energy, friction, or any other expenditure of energy, thus inducing the degree of molecular motion or vibration in such a body, as respects frequency and amplitude requisite for recognition as heat for heat, as previously shown, is a form of vibration in matter In other words, by the transformation of different forms of energy—mechanical, electrical, radiant, or chemical—heat is evolved

The methods of employing or inducing *conversive heat* which are of importance in therapeutics consist in the regulated employment of radiant *energy from luminous sources as from the sun from various types of* artificial light applicators and from the passage of electrical currents through the tissues—thermopenetration or diathermy

When radiant energy passes through a transparent medium which offers a minimum of resistance as in case of the sun s rays passing through ether, air, or glass little or no heat is evolved When the radiations impinge upon matter that offers resistance, heat is produced by transformation into heat energy by conversion The earth s atmosphere is heated by convection from the heated surface of the earth

Of the sun s rays that pass through the glass window pane, only the ultraviolet are absorbed and those rays are of so great frequency and short wave-length that little or no heat is produced When light of considerable candle power is passed from within a blue glass bulb it becomes very hot from absorption of the luminous radiations or frequencies

The absorption of the ultraviolet rays by glass renders heliotherapy by the sun's rays a farce except in the open air Dr Hess found it necessary to make this observation when considering an erroneous reference to the treatment of *rickets* through the glass windows of a solarium

In the work of an eminent author an illustration appeared showing a patient receiving heliotherapy through a closed window This is mentioned to emphasize two facts (1) that ultraviolet rays do not pass through glass, and (2) that heliotherapy is always presumed to be taken in the open Furthermore if the housewife is to derive in her apartment the beneficial sterilizing effects of the ultraviolet rays, the sunlight must enter through the open window

The *penetration* of the visible spectrum of radiant energy *from luminous sources* is the same from all sources of *white light* The radiation of one candle will be projected as far as that from a source of greater candle power but with an intensity relative to the volume of light passing

The rays of the solar spectrum vary in penetration heat production warmth, wave-length and frequency the penetration increasing with the wave-length from violet to red and diminishing with the frequency from

red to violet In other words, "the penetration is as the wave-length and inversely as the frequency" When an electric light is held in the mouth or observed through the hand, the visible rays that appear in greatest abundance are the red

Of the greatest abundance and increasing wave-length are the invisible infra red rays, which pass to a much greater depth into the tissues than the visible rays, and are, therefore, of greater value in point of heat production than the visible spectrum There is a marked difference in the extent or degree of penetration of the radiations from various artificial sources of light, those from the electric arc and carbon filament incandescent lamp being richer in infra red and red rays than those from tungsten lamps The former also are properly the *deeper* therapy lamps There are no deep therapy lamps' except in conformity with the physics of light, though commercial nomenclature has sometimes assumed the contrary, thus misleading the uninformed purchasers of apparatu

The demonstrated penetration of the tissues by the radiations of the visible spectrum is about one inch, varying with the density and vascularity of the tissues—fat being least resistant and muscle and bone most resistant Bone is no more resistant than muscle, as it is readily demonstrated that the visible incandescent rays penetrate the antrum and sinuses If so, they also penetrate the mastoid and to the middle ear, a fact which is furthermore clinically verified It is plain from the preceding that reflected light is available for producing heat in the tissues to a considerable depth, the energy naturally waning as the radiations proceed

For therapeutic purposes the radiations should be projected from artificial sources in practically parallel or slightly divergent beams Focused or convergent radiations are too intense to be endured and, therefore, are not practical, and yet manufacturers have long persisted in putting on the market lamps that always reflect a focus

Induction of Conversive Heat—Induction by high frequency electric currents is a subject of profound interest in the light of accumulated therapeutic accomplishments

All electrical currents produce heat as they pass through matter, the degree of heat varying with the amperage, potential frequency, resistance, and directness of the current or conductivity of the path The constant (galvanic) current of sufficient wattage, that is, volts times the amperes, to produce thermic effects of therapeutic value in the tissues is destructive to the life of the tissues acted on, and is, therefore, out of consideration as a means of producing heat effects, except for the local destruction of neoplasms The static sinusoidal, and induced currents fill other roles in therapeutics, not essentially thermic

D Arsonval Currents—The e cur ents are variously produced by many types of high frequency apparatus, including open and closed circuit

transformers Ruhmkorff coils and static machines in combination with two condensers, a solenoid connecting the condensers and a variable spark gap all in circuit Types of apparatus for producing these currents now on the market are too numerous to mention

D Arsonval s original apparatus consisted of a Ruhmkorff coil, two Leyden jars and a coil of several turns connecting the outer coatings of the two jars the inner coatings being connected with opposite terminals of the Ruhmkorff coil Between current terminals connected with the inner coatings of the two condensers—the jars—was an adjustable spark gap that could be lengthened and shortened so varying the resistance in the circuit to vary the dosage The current thus produced when passed from the terminals of the resonator solenoid or coil through connecting cords to electrodes is oscillating or alternating in character at a rate of oscillation giving a frequency of more than 10 000 per second There are two oscillations in each frequency When the frequencies exceed 10 000 per second muscular responses cease and the only appreciable effect to the senses is heat, if all contacts are closed and no sparking occurs in the circuit except at the spark gap The only possible accident that can occur is from an excess of heat relative to the size of the electrodes or from careless removal of an electrode by the patient when the current is in operation

Nagelschmidt first demonstrated that with a powerful current passing between the two poles, there was no electrolysis—from a KI solution, iodin was not thrown down Tesla demonstrated that with tremendous potentials there was no danger to life

With the modern types of transformer apparatus provided with multiple spark gaps and with means of control provisions exist for scientific methods of producing with safety and practical utility therapeutic administrations of *conversive heat* into the deepest recesses of the body

Direct or Bipolar D Arsonval Current —This term was first used by the writer in the second edition of his work *High Potential Currents of High and Other Frequencies* published in 1910 and there described The term is still in common use and interchangeable with those of thermopenetration and *diathermy*—heating through—applied to this method of heat therapy

The passage of the current through the body was also designated by the author as the *direct* d Arsonval method in contradistinction to the indirect method or autocondensation when the patient is connected to one pole and insulated from the other on the couch The passage of the high frequency current evolved by the d Arsonval method or diathermy heats the tissues to practically a uniform degree in the path between two electrodes placed on opposite surfaces if the surfaces of the electrodes are practically parallel so that the margins nowhere approach each other otherwise the current would take the shortest route, following the path of

the least resistance, and the effect would be greater from the contiguous margins

The heating of the tissues is derived in accordance with Joule's law[1] of conservation of energy. It is questionable whether all of the heat is produced by the resistance of the tissues to the passage of the current in the fulfillment of that law, or whether the joint action of the rapid oscillations at a rate of frequency and amplitude comparable to heat account in part for the heating. This latter view is suggested by the conservation of a reasonably small current of very high voltage passing into the resonator, as compared with the meter readings. In one of his early experiments the writer derived a hot wire meter reading with the d'Arsonval arrangement connected with an 8 plate static machine of 225 milliamperes, whereas the current output of the machine did not exceed 1/4 milliampere, but was of very high potential. Under these conditions it would seem that the conservation may be due in a measure to induced current oscillations that represent the amplitude and frequency characteristic of the vibrations of heat. A hot wire meter is calibrated with a constant current meter, with the constant current passing through the two meters. The meter readings, however, from the passage of the high frequency current through the hot wire meter, do not conform in terms of current strength to the constant current readings, but in terms of heat.

That the heat effect is practically uniform between two electrodes of equal size is readily demonstrated by cooking a thick piece of meat or a potato between two small disc electrodes, when, with sufficient current for the requisite time, it will be found, on cutting through a section, that in either case the cooking process has been practically uniform from side to side.

When applied over the skin, which is more resistant than any other structure in the path, except possibly the outer thin compact structure of bone or of ligament, any temperature that will be tolerated by the skin is negligible as to any danger to the underlying structures.

Physics.—The physical characteristics and the physiological effects of heat may be considered as depending upon: (1) local effects as applied to the surface of the body, whatever the source of the heat, (2) the reflex effect derived from the stimulation of the nerve end plates as affecting the deep centers with the derivation both of local effects and stimulation of the vital processes of respiration and circulation, and (3) the thermic

[1] When heat is transformed into any other kind of energy, or vice versa, the total quantity of energy remains invariable; that is to say, the quantity of heat which disappears is equivalent to the quantity of the other kind of energy produced and vice versa.

The number of units of mechanical work equivalent to one unit of heat is generally called the mechanical equivalent of heat, or Joule's equivalent, and is denoted by the letter J. Its numerical value depends on the units employed for heat and mechanical energy respectively.

effects of the heated blood stream as activating the general functions and activities of the organism

Effect of Local Stimulation.—Local stimulation by heat or cold of the peripheral nerves is followed by a prompt reflex response of the vasomotor mechanism, with an increased flow of blood to the tissues stimulated following the natural law of reflex response to stimulation. Hyperemia, promptly induced, is the natural phenomenon for the preservation of the tissues from burning through the application of heat, or freezing through exposure to cold. This is observed in the intense redness of the skin when exposed to radiant heat or conductive heat and in the reaction to cold with intense hyperemia. In both cases the natural reflex response serves to maintain the skin at the normal temperature. The influx of blood at normal temperature maintains the temperature of the skin at the temperature of the blood stream as long as the body's reserve is adequate to meet the requirements. In the case of exposure to heat, the latent heat of absorption from the evaporation of perspiration is an added source of protection, also favored by the hyperemia produced as an example of the efficiency of these natural provisions. We have a significant example of this in the therapeutic administration of *dry heat* at 400° to 500° F. when, by means of the absorption of perspiration by Turkish toweling wrapped about a part, the skin is protected from collection of perspiration and from consequent heating and burning of the surface.

The local effects of heat as shown are: (1) to induce an active local hyperemia, (2) to increase the elimination of moisture through the sweat glands and of sebum through the sebaceous follicles, and (3) to expand or relax the tissues, thus relieving skin tension, pressure and pain.

Reflex Effect on Deep Centers.—The reflex effect on the deep spinal centers is one of the most remarkable and beneficial effects of intense heat superficially applied when the powers of resistance are lowered, or of the stimulating effects of cold to the surface when the resistance is adequate to respond. The response to both heat and cold is the acceleration of the heart's action and respiratory movements to meet the increased demands on the body's energies. As illustrating the first type of responses I will cite the recovery of a patient whose condition was critical.

The following observations made by the writer with Drs. Grad and Munday would seem to fortify this hypothesis. A patient *in extremis* from general septicemia three weeks after a difficult surgical operation with the characteristic feeble pulse, livid countenance and a temperature of 105° F., was wrapped by the usual method in Turkish toweling and placed in a body hot air apparatus at a temperature of 300° to 350° F. and after thirty minutes removed with a full strong pulse, a marked hyperemia of the skin and mouth temperature of 103° F. Eight hours later the temperature was normal, and the patient was convalescent in ten days. This extraordinary result could only be explained by (1) the

induction of an active phagocytosis with a positive chemotaxis, (2) stimulation by heat of the deep spinal centers, particularly the cardiac and respiratory, and (3) the elimination of toxins and other bodies through the agency of the profuse perspiration induced by the high temperature

Another case reported illustrates remarkably the result of peripheral heat stimulation as follows

"Dr Herman Grad reported a case, that of a child who was brought into the Women's Hospital in a state of collapse The light bath as described was placed over her body, when a prompt reaction and improvement was set up in her physical condition The diagnosis of the case was rendered uncertain, the state of collapse forestalling an exploratory operation *It was found that, if the light was continued, she was revived, the* low condition returning if it was discontinued The light administrations were accordingly continued for several days, when unexpectedly the child passed from the rectum several inches of the small intestine The case had been one of intussusception The patient made a complete recovery, which would have been impossible except for the employment of radiant light and heat during the state of collapse"

These cases are remarkable examples of the profound therapeutic effects derived from the administration of heat to the periphery as a means of maintaining or restoring the vital processes It is by this principle, as will be shown later, that heat contributes to the revival of the functions of the heart, as stimulated from the periphery in conditions of failing heart in the asthenic type of fevers, such as pneumonia For the same reason its administration is contra indicated in decompensated valvular heart lesions

The reflex effect of the cold plunge or shower in the conditions of health is refreshing and, if these measures are systematically used, the vigor of the circulation and peripheral resistance against exposure to cold are increased

Thermic Effects—The thermic effect of convective heat, as affecting the increased heat carried by the heated blood to all parts of the body, *is to increase the general metabolism of the organism by accelerated circulation of the heated blood* with general increase of elimination through the urine and perspiration, with solids in solution A general condition of well being is also induced due to the increased activity under heat stimulation of the body's functions, when not continued to a degree of overstimulation which will depress or overfatigue the cells of the body

Action of Conversive Heat—The action of conversive heat is quite different, applied locally for therapeutic purposes from the action of either *convective heat* or *conductive heat* The object and purpose of administration of radiant light and heat is to produce a local penetrating

effect, with absorption of radiant energy for the relief of local conditions. The indication of first importance for its employment is the induction of active local *hyperemia* in the tissues beneath the surface.

HYPEREMIA

Hyperemia, induced by radiant energy and high frequency currents, will be found to fill one of the most important fields in physical therapeutics. The three significant effects of hyperemia, superficial or deep, are: (1) increased nutrition to tissues that are impaired, from the passage of nutritive pabulum in the blood stream to the parts; (2) increased metabolism from the activation of fixed cells under stimulation of the energy applied, and from the effects of the activated blood stream; and (3) increased phagocytosis from the greater number of phagocytes conveyed into the tissues, with a probable increase in chemotaxis.

1. Increase of Nutrition.—The attending increase of nutrition is favored by increase in both the anabolic and catabolic processes by which waste matters are hastened on from the lymph spaces through the lymphatic channels and by the greater activity of the end organs in appropriating the nutrition. Elimination promoted by the increased activity of the sweat glands and increased elimination by the other emunctories is excited by the heat of convection as conveyed throughout the organism. By the administration of *conversive heat* the heated blood stream conveys excess heat by convection, thus equalizing the temperature throughout the body by evaporation and cooling at the surface. There is local increased circulation in the tissues throughout the paths of the high frequency current and to the depth that radiant energy penetrates, and the fixed tissue cells will be heated by the direct action. By the warming of the tissues and the passing of fluids in the fields so energized the anabolic processes of nutrition will be accelerated and local tissue building or repair will be stimulated.

In the authorized translation of Bier's *Hyperemia as a Therapeutic Agent* published by A. Roberts, 1905, the subject of hyperemia is treated largely from the point of view of a measure capable of effecting the destruction of bacteria, and acting as a solvent to promote absorption. He refers also to its nutritive effects. In this work, however, he lays greater stress upon its effects upon conditions of local stasis, although these are better managed by electrostatic modalities which produce tissue drainage. The failure of application of heat to remove infiltrating materials where marked stasis exists has been generally established. By the mechanical effects of the whirlpool bath it is often possible to relieve to a degree the infiltration from swollen stumps, but in general the

application of heat for restoring circulation and nutrition, where stasis is firmly established must be conceded as ineffective

2 Metabolic Effects—These, as shown, are the effects upon which increased nutrition depends and are, therefore, considered conjointly. Willy Meyer says "hyperemic treatment has been found most useful in that it favors the absorption of exudates and pathological tissue changes of various kinds. There is no other method that is superior to hyperemic treatment in point of gentleness and painlessness of application, as well as a *tendency to relieve pain*." *The field of indications for the employment of hyperemia for increasing tissue metabolism is one of the leading indications for the use of thermotherapy*

3 Effects of, on Infection—Such effects constitute important indications for the use of measures which induce this physiological effect. In this connection it will be observed that these effects are not alone due to the increased influx of blood with an increase in the number of phagocytes in the tissues, but that certain bacteria, which are susceptible to heat or light are destroyed *in situ* an effect of conversive heat of great value in the treatment of local infection. The writer has shown in his previous contributions to this subject that some types of infection, notably the staphylococcic, streptococcic, and gonococcic, are affected locally by the administration of radiant energy, due probably to the combined light and heat effects. The ultraviolet rays, while only mildly thermic, are the great natural antiseptic, acting to destroy all forms of germ life with which they come in contact. It is a beneficent fact that the ultraviolet radiations destroy germ life on the earth's surface and in water exposed to the sun's rays.

In acute and subacute infectious conditions alone, or in connection with other measures which inhibit germ processes or increase local hyperemia or both, it (1) increases local hyperemia in the region of infection with a relative increase of leukocytes—the phagocytes, (2) inhibits the activity of the germs through the intensity of the radiant light and heat radiations and (3) stimulates the elimination of toxic materials, local and diffused by the induction of perspiration and increase in tissue oxidation. By these means local phagocytosis is stimulated, the germs inhibited and devoured, and the toxic material eliminated

Derivative Effects—These are induced when extensive exposures are made rendering the surface hyperemic, through prolonged application of *high-candle-power incandescent lamps over front, back, and sides*, or by the arc or incandescent light bath, and through the coincident profuse perspiration induced (1) lessening the quantity of blood in congested regions and the larger arteries and veins, (2) lowering arterial tension, (3) relieving an overworked heart, and (4) coincidently promoting extensive elimination of the retained products of poor metabolism

There are several possible factors which may be active in effecting

the resolution and healing of septic processes as induced by the administration of hot applications (1) The increased hyperemia occurring with tissue relaxation which is present during the early part of the heat administration, brings into the involved tissues a greater number of leukocytes in proportion as the volume of arterial blood is increased, together with an increased amount of oxygen so essential to local metabolism and prompt diapedesis of the leukocytes (2) The profuse local and general perspiration induced alters toward normal the fluids in the field of involvement and coincidently eliminates to an extent other materials affecting the constitutional condition of the patient, possibly favoring a general phagocytosis (3) The action of heat upon the superficial tissues may coincidently inhibit the activity of the microbes or, by altering the constitution of the fluids as suggested, produce a larger degree of positive chemotaxis (4) The production of more active metabolism in the tissues will tend, also, to increase the natural fortifications of the involved tissues, increasing the activity of the macrophages

Zinsser says of Chemotaxis The motion of the leukocytes toward the invading substances indicates a sensibility on the part of the cell to changes in its environment incited by the foreign agent and since the stimuli most likely to reach the leukocytes and bring this alteration in the direction of their movements are chemical in nature the phenomenon is spoken of as 'chemotaxis Since the change of direction brought about in a moving cell by such influences may be such as either to attract or to repel the term positive chemotaxis is used to designate the former and that of 'negative chemotaxis the latter The property of chemotaxis is of vital interest in the present connection since, whatever may be our opinion regarding the relative values of phagocytosis and serum protection in immunity, the great importance of the phagocytic process cannot be questioned and any agency which repels the approach of the phagocytes must be a detriment, while any factor which attracts them is, of necessity, a powerful means of defense

Willy Meyer says Since it has been demonstrated that, by increasing the inflammatory symptoms a beginning infection can be made to subside we ought more generally to practice abortive treatment of incipient troubles of this kind for instance of incipient phlegmons or furuncles

While it is not possible to suppress every infection before pus is formed there is no question that by means of artificial hyperemia suppuration can be avoided in a larger percentage of cases than by any of the other therapeutic measures at our disposal

In cases in which suppuration is unavoidable even with the aid of artificial hyperemia owing to the intensity of the infection, Bier s treat

ment enables us to accomplish with small incisions what formerly could be achieved with large ones only This has been shown by manifold practical experiences The advantage is obvious

"The increased supply of blood hastens markedly the course of a suppuration, inasmuch as it favors the rapid development of demarcation and separation of necrosed portions in soft tissues as well as in bones"

Advantages of Hyperemia—The advantages of hyperemia produced by conversive heat or diathermy, are marked as against the Bier method employing of dry heat—the method referred to in the previous quotation by Willy Meyer Penetration deep into the infected areas relieves many cases in which the heated air method will fail, and, furthermore largely limit suppuration instead of favoring it, as stated by Willy Meyer This is accomplished by bringing the large number of phagocytes into the infected field under conditions of light and heat unfavorable to the bacteria, and so terminating further developments

From the foregoing physiological effects, and from the effects of heat therapy upon bacteria, we have a foundation upon which the principles of heat therapy are well established

Heat in one form or another has been used in therapeutics since the earliest times It is not probable that any measure that gives so much relief from pain as heat could have failed to be recognized by intelligent human beings

The sun's rays, in the form of sun baths, were naturally the first source of heat employed It is surprising, however, how little their effects have been understood

On the field of battle where the wounded lay in the sun's rays and were relieved from degrees of suffering, it must have been generally appreciated, except for the discomfort caused by continuous exposure to extreme heat It is natural for all forms of life to withdraw from the intense heat of the sun's rays at midday Nor has the therapeutic value of radiant light and heat as derived from artificial sources been duly recognized Its effects are often not appreciated except by *those trained in the* indications and methods of application Poultices, hot baths, Turkish and Russian baths, mud baths, emplastrums, hot water bags, wet dressings and hot douches are measures which have been in common use for many generations These forms of application act upon the surface and are all *subject to the principles of convection*

A certain enthusiasm has been created in the idea that water heated from the earth possessed superior curative qualities It is claimed, and correctly, that some such waters contain radium or some other radioactive substance, but, so far as known not in sufficient degrees to produce therapeutic results The virtue of natural hot baths probably is not so

great as the public is often led to believe for the real virtue of heat need not be sought at far away points except to indulge the fastidious taste or for psychological effects Under systematic management, the same physical effects can be derived at any properly managed hydropathic institution sanitarium, or, often even in the home

APPARATUS

Ultraviolet Rays —The apparatus employed for the administration of radiant light and heat and the high frequency current has been developed or improved until at the present time the more exact knowledge of their requirements indications and methods of employment seem to have reached standards approaching perfection

The introduction by Neils Finsen of the electric arc for the development of ultraviolet rays in the treatment of the forms of lupus marked the earliest type of apparatus introduced types now superseded by the air cooled and water cooled ultraviolet lamps of the Cooper Hewitt mercury vapor type

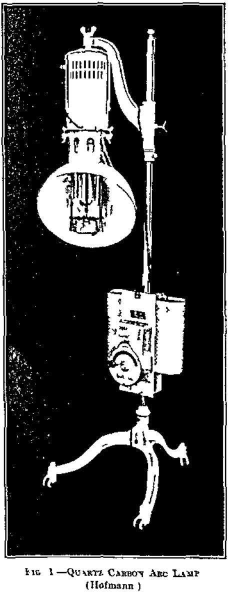


Fig 1 —Quartz Carbon Arc Lamp (Hofmann)

Hofmann Quartz Carbon Arc Lamp (Fig 1) —A study of the refinements of the quartz carbon arc lamp introduced by Emil Hofmann Ph D M I reveals that the carbon pencils which burn in a semivacuum permit an increase of voltage and decrease of amperage which result in a 2 inch crescent unusually rich in ultraviolet radiations of higher frequency

The radiant energy emerging through the quartz globe includes all wave lengths from the infra red to the ultraviolet of 2,320 Angstrom units (232 millimicrons) inclusive With the semiquartz globe furnished, the spectrum emitted includes all the wave lengths from the infra red through the entire visible spectrum to the ultraviolet of 2,900 Angstrom units (290 millimicrons) inclusive As these globes are interchangeable, a convenient means is provided for the selection of ultraviolet wave lengths to suit a given condition At the same time the entire visible spectrum is available and also the infra red

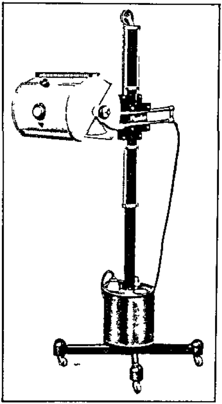


Fig —Air cooled Mercury Vapor Lamp

The quartz carbon arc operates on 110 or 220 volts with either alternating or direct current and uses 10 amperes of current

Uniform quality of radiation is secured by the use of a sensitive electromechanical device which automatically maintains a luminous crescent of constant length

The original carbon arc, as used by Finsen, was an open arc with a short crescent and poisonous gases produced had to be conducted to the open This lamp gives an abundance of the shorter irritating ultraviolet rays, and at the same time long or mild ultraviolet, together with a continuous spectrum, equal to the sun and the infra red rays with a mild pleasant thermic radiation This phenomenon prevents excessive burning in time exposure

Lortet and Genoud later introduced a lamp for the same purpose, the London Hospital lamp which consisted of an arc light constructed to reflect its rays through two rock crystal plane lenses placed on either side of a chamber, through which water was flowing to maintain a temperature which would permit pressure against the bare skin without giving discomfort to the patient In this manner it was possible to render the skin anemic and so permit the penetration of the ultraviolet rays more deeply into involved areas The X ray later largely displaced the latter type in the treatment of infections of the skin

The later invention of the *mercury vapor lamp* by Cooper Hewitt

of New York, and the adoption of the quartz tube by Dr Kromayer, of Vienna, introduced an apparatus which permits the passage of the ultra violet rays These lamps, both air cooled and water-cooled afford a more potent means of administering the ultraviolet rays with greater numbers of these rays and devoid of the orange red and heat rays These lamps now fill an important place in the therapeutics of infections and produce other effects upon the blood and metabolism (Figs 2 and 3)

During the closing years of the nineteenth century, Dr Margaret A Cleaves of New York introduced the use of the *marine searchlight* as a therapeutic means of administering radiant energy of high and varying candle power The radiations reflected from iron-cored carbon electrodes are rich in all of the rays of the solar spectrum important in therapeutics She also introduced the use of the arc light bath which was advocated in the treatment of tuberculosis

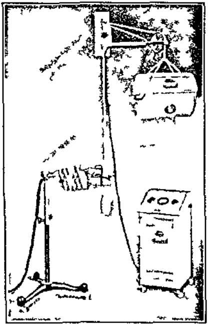


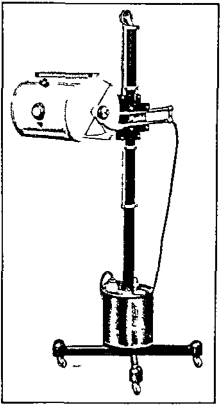
Fig 3—Combination Air cooled and Water cooled Quartz Lamps for Alternating Current

Minin a Russian physician who advocated the use of reflected light passed through a natural blue glass bulb or plate for relief from pain introduced about this time the Minin lamp This form of administration has been variously reputed to possess marked therapeutic analgesic effects perhaps largely due to the increased reflected heat generated in the glass bulb which becomes intensely hot from the absorption of the other visible and infra red rays Some authorities, however still maintain that there is an analgesic effect derived from the blue rays which the author has been unable to confirm

Incandescent Light—Incandescent high-candle-power lamps were introduced to the profession in 1904 in the form of the so-called leucodescent lamp This apparatus was widely advertised and exploited, which was undoubtedly instrumental in calling attention to the value of intense reflected incandescent light radiations

The idea that *candle power* contributes to penetration has been largely derived from the introduction of this form of apparatus whereas the candle power of radiant energy has nothing to do with the penetration but rather with the intensification of the penetration which is limited

The radiant energy emerging through the quartz globe includes all wave-lengths from the infra red to the ultraviolet of 2,320 Angstrom units (232 millimicrons) inclusive With the semiquartz globe furnished, the spectrum emitted includes all the wave lengths from the infra red through the entire visible spectrum to the ultraviolet of 2,900 Angstrom units (290 millimicrons) inclusive As these globes are interchangeable, a convenient means is provided for the selection of ultraviolet wave-lengths to suit a given condition At the same time the entire visible spectrum is available and also the infra red



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The later invention of the *mercury vapor lamp* by Cooper Hewitt

of the cabinet bath, so as to carry away the moisture and other emanations and provide a steady influx of fresh air (Fig. 4).

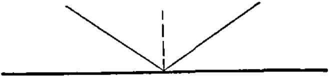


Fig. 5.—Illustrating the Law of Reflection.—The Angle of Incidence Equals the Angle of Reflection.

Small Therapeutic Lamps and Applicators.—In the writer's work *Radiant Light and Heat and Convective Heat* and in the first edition

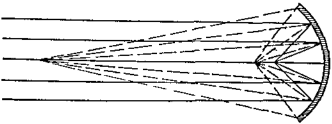


Fig. 6.—Reflection from a Parabola. This shows the relative position of the light to the reflector as producing convergent, parallel or divergent rays in conformity with the law of reflection.

of *Therapeutics of Internal Diseases* he called attention to the importance of reflecting the light rays in parallel or in slightly divergent beams

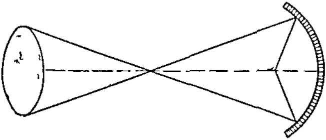


Fig. 7.—Incidence of a Focus with the Dark Spot Beyond the Focal Point. A circle indicates the dark field at a far point.

(Figs. 5, 6 and 7). The necessity for this was suggested by the fact that many lamps on the market reflected a focus at a short distance from the lamp and so rendered impossible its therapeutic employment unless

by the surface toleration of the skin of the patient to the heat By the use of intense forms of incandescent radiation, from which the ultra violet rays are eliminated by passage through glass, the thermic and luminous effects of radiant energy have been thoroughly investigated and their value as therapeutic measures verified

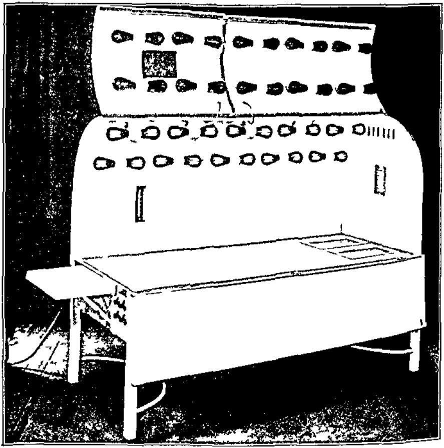


FIG 4—RECLINING BODY LIGHT BATH

At about the time that the high candle-power lamps were exploited, Dr Kellogg at the Battle Creek Sanitarium introduced the incandescent *light cabinet baths* and became an ardent advocate of sunlight baths in the nude state

Light baths have gone through a period of evolution and change, until now a high state of perfection has been attained both in point of construction and efficiency The introduction of ventilation of this form of bath, by the suggestion of Dr Titus, has been recognized as important, in order to allow the escape and change of air during the administration

treatment, for, as Dr Byron S Price has well said, the term baking' is not only absurd but wholly misleading Baking means cooking and necessitates an elevation of temperature in the interior of the substance that is being baked to a degree of 160° F or higher, whereas the body

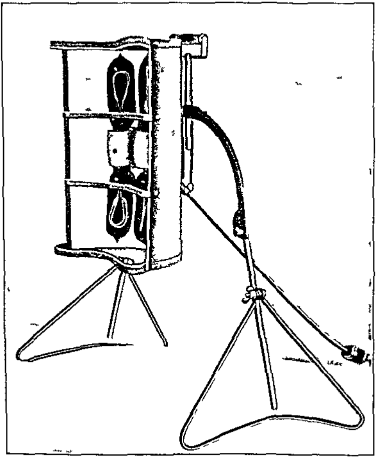


FIG 10—SMALLER TYPE OF MULTIPLE LIGHT REFLECTOR MADE ADJUSTABLE FOR CONVENIENCE IN TRANSPORT

temperature general or local probably never exceeds 106° F under the most intensive treatment'

The incandescent light bulbs employed in these lamps as in all therapeutic lamps which aim to produce the greatest degree of heat penetration, are of the carbon filament type and as previously stated the so-called deep therapy lamps are only so in name, as penetration depends upon the quality or richness of the rays in the waves of greater wave-

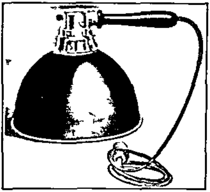


FIG 8—SMALL HAND LAMP PROJECTING PARALLEL OR SLIGHTLY DIVERGENT RAYS

rapidly moved over the surface. A lamp of suitable type has now been perfected (Figs 8 and 9) This enables the operator to place the lamp in position at a distance at which the temperature can be tolerated for requisite periods of time

Multiple Light Reflectors—The need in therapeutics for a uniform reflection of light over considerable surfaces, such as the trunk, resulted in the manufacture of a type of apparatus that had been introduced in the Woman's Hospital in New York City by Dr Herman Grad The first lights manufactured were employed for warming up the bodies and limbs of the young victims of poliomyelitis, the treatment of whom at the request of Dr Reginald Sayre, was placed under the writer's direction in Bellevue Hospital New York City, following the epidemic of 1912 These lamps of different form (Figs 10 and 11) were extensively employed in the Physiotherapeutic Departments of the Government Hospitals during and following the late War and probably accomplished more toward bringing the profession to the recognition of the value of radiant energy in therapeutics than would have been otherwise possible

An error in the terminology of this form of treatment, "baking" was instituted at this time No greater error in terminology could be made than the employment of the term 'baking' for this form of

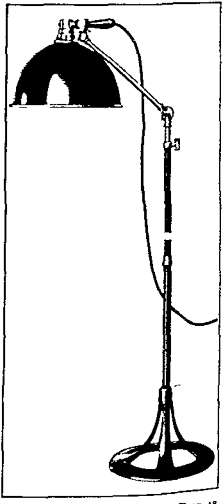
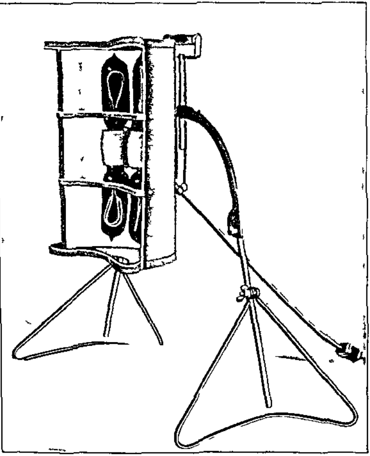


FIG 9—LARGER LAMP OF SAME TYPE AS FIG 8 WITH STAND

treatment, for as Dr Byron S Price has well said, "the term 'baking' is not only absurd but wholly misleading. Baking means cooking and necessitates an elevation of temperature in the interior of the substance that is being baked to a degree of 160° F or higher, whereas the body



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length and lower frequency, particularly the infra red rays, which are far more abundant as produced from the carbon filament incandescent bulbs

An adjustable form of incandescent lamp, reflecting parallel or slightly divergent rays and of moderate cost, is the lamp shown in Figs 8 and 9 on page 366

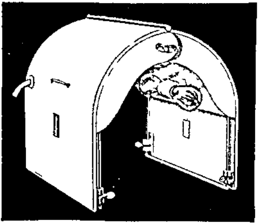

Fig 11 —Larger Type of Multiple Light Reflector

Dry hot air Apparatus—Dry hot air apparatus is used to administer dry hot air and is constructed for gas and electrical heating, and for limb and body applications

Body Type—The body type of apparatus (Fig 12) can be used only by institutions, and is better heated by gas Bunsen burners than by electricity A properly constructed apparatus should be provided with means for opening it and pushing the patient into the opened receptacle or should

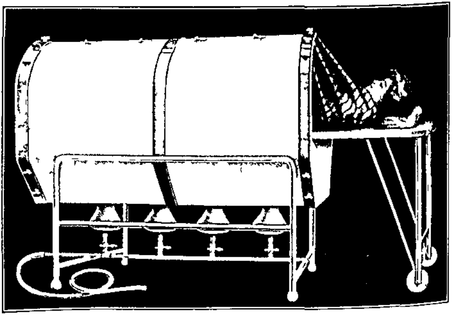

Fig 12 —Gas heated Body Dry hot air Apparatus

open over the reclining table The heat should be furnished through a gas pipe at least one inch in diameter, in order that it may be possible

to insure adequate pressure to raise the temperature to 500° F Turkish toweling wrappings and gowns are essential parts of the equipment Experience has shown that there should be an upright shield of wood provided to prevent the overheating of the patient's feet. It is possible that a

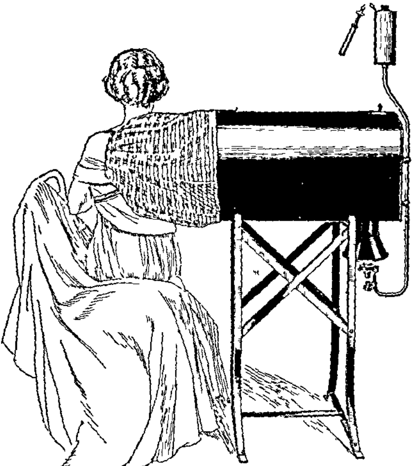

FIG 13—DRY HOT AIR APPARATUS FOR ADMINISTRATION OF HEAT TO LEG OR ARM

body apparatus could be constructed to supply heat by electricity but this is a slower method of getting up the requisite heat, and requires expensive resistance coils for heating in order to supply the requisite 500° F

Extremities Type—For local applicators for the extremities (Fig 13) the gas apparatus is practical and costs far less than the electrical heating

length and lower frequency, particularly the infra red rays, which are far more abundant as produced from the carbon filament incandescent bulbs

An adjustable form of incandescent lamp, reflecting parallel or slightly divergent rays and of moderate cost, is the lamp shown in Figs 8 and 9 on page 366

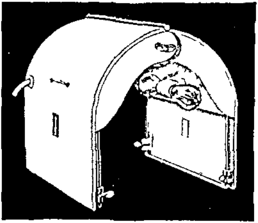

FIG 11—LARGER TYPE OF MULTIPLE LIGHT REFLECTOR

Dry hot air Apparatus—Dry hot air apparatus is used to administer dry hot air and is constructed for gas and electrical heating and for limb and body applications

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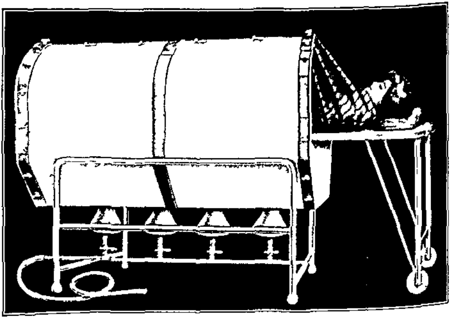

FIG 12—GAS HEATED BODY DRY HOT AIR APPARATUS

open over the reclining table The heat should be furnished through a gas pipe at least one inch in diameter, in order that it may be possible

water is thrown into stronger commotion effecting a greater degree of mechanical effect to parts under treatment (Figs 15 and 16) than the earlier type of apparatus

Apparatus for giving douches and jet sprays is employed in institutions, its principal effect being to produce skin reaction as hot or cold

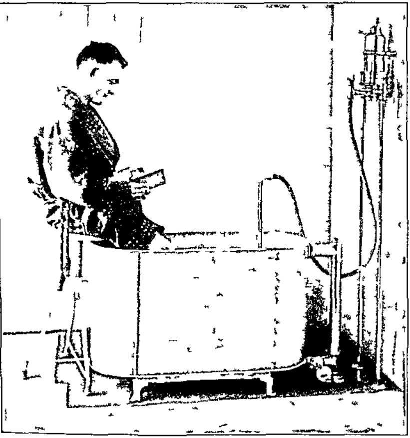

Fig 15—The Whirlpool Bath (Courtesy Dr Bardwell)

jets are applied with pressure to the body A very active superficial hyperemia of the tissues of the skin is the result but this may often be as well or better obtained by the employment of body administrations of radiant light and heat In the treatment of the spinal cord or other conditions of the nervous system it cannot be compared in efficiency with the static current.

High frequency Apparatus—The earliest type of high frequency apparatus designed by d'Arsonval consisted of a Ruhmkorff coil attached

devices and is less expensive to operate To meet every demand an apparatus open at both ends for applying heat to the knee-joint (Fig 14) has been made by the manufacturers This apparatus is only of value to those who have not the more effective facilities for treating arthritis by diathermy or the static currents

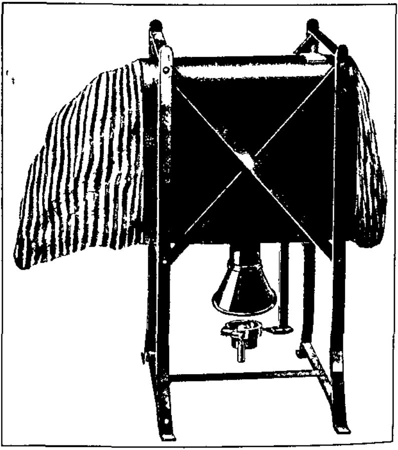

FIG 14—THE GAS HEATED DRY HOT AIR APPARATUS FOR TREATING THE KNEE OR ELBOW JOINT

Hydrotherapeutic Apparatus—The facilities for administering whirlpool baths and cold and hot packs are the more practical types of apparatus required for hydrotherapy adminstrations

The whirlpool bath, which was designed and perfected in the hospitals during the Great War, has filled a useful role as a means of producing a peculiar water massage to inflamed tissues The value of this apparatus has been greatly enhanced by Dr Bardwell's design The bath should be made of Monell metal which does not require painting or finishing This should be made in the original form, whereby the

to a resonator for transforming the high voltage current of the coil to the high frequency current (Fig 17)

The resonator consisted of two condensers either Leyden jars or other condensers, in which tin foil was insulated between layers of insulating material A solenoid or coil connected the outer coatings of the jars or a corresponding arrangement was made if other types of condensers were used A spark gap which might be varied in length, single or multiple was placed between connections between the two inner coatings The jars, solenoid and spark gap being arranged in series with the inner coatings of the condensers were connected with the source of the current on either side A solenoid or coil connected the inner coatings (Fig 18)

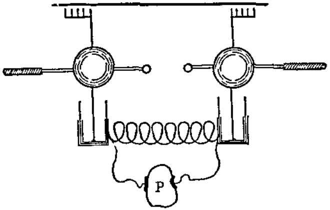

FIG 18—ARRANGEMENT OF CONDENSERS SPARK GAP AND SOLENOID This shows arra g ment itl pat ent in circuit

The same principle as concerns the resonator is employed with all modern types of apparatus but with greatly improved facilities

Modern Types—Modern types of apparatus used for the production of high frequency currents employ the alternating current and consist of a large capacity oil immersed transformer in which the primary and secondary are wound upon two parallel bars insulated from each other The primary wire receives the current from the A C commercial current, or the direct current transformed to alternating by a rotary converter Insulated wire is wound in relatively few turns around the primary, and very fine insulated wire in the secondary is provided with the requisite number of windings or turns and fineness to give the necessary inductance and impedance to produce the desired potential or voltage of the apparatus The current thus transformed is conducted into the resonator In the construction of these transformers attention is required by the manufacturers to adjust the windings and condensers to a true resonance,

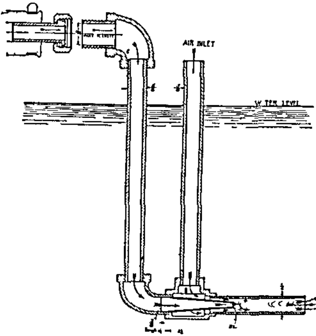

FIG 16 —ARRANGEMENT FOR PRODUCING THE AGITATION OF THE WATER IN THE WHIRLPOOL BATHS (Courtesy Dr Bardwell)

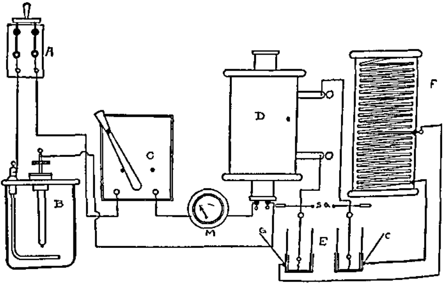

FIG 1 —COMPLETE COIL EQUIPMENT FOR HIGH FREQUENCY AND X RAY APPARATUS OF THE D'ARSONVAL TYPE —A line switch B interrupter C rheostat D Ruhmkorff coil E Leyden jar condensers F high frequency solenoid G1 and G d'Arsonval terminals SG high frequency spark gap M meter

modern types of apparatus and of an equal capacity in the closed condensers

The Oudin terminal of a resonator is an additional requisite An attachment to one terminal of the d Arsonval circuit is made consisting of a coil of the Guilliminot type that is, the windings are arranged from the center to the periphery or vice versa, and they are of a sufficient number of turns to give a three to five-inch discharge from the Oudin terminal This attachment is used for administering discharges of higher voltage than from the d Arsonval terminals and should be constructed with adjustments to give a range of varying discharges from the cold spark, which will not ignite parchment paper to a heavier fulguration or burning spark The latter is applied for administering currents with vacuum or non vacuum electrodes and the hot fulguration spark, while the former discharge is used for administering the desiccation spark for the removal of condylomata epitheliomas, keratoses and lupus patches

Electrodes for Special Applications—A large variety of electrodes has been designed for special applications non vacuum or vacuum electrodes adaptable to the various cavities of the body as well as electrodes for surface treatment Electrodes for administering diathermy currents are best made of composition metal of a gage that will not crumple, but that will remain relatively smooth—in thickness approximately twenty two B and S gage The same material is used for other electrodes These are made in different shapes usually rectangular with rounded corners and are adapted for applications to varying surfaces and conditions The edge is rolled up or evenly rounded so that there will be no discharge of fine sparks or sprays from rough edges or angles which would give annoyance to the patient and make the administration impossible These include the more practical types of metal surface electrodes, which can be prepared and used in individual cases as required by the operator

Disc electrodes provided with handles are furnished by manufacturers, but these are not readily applicable for it is not convenient for the patient or operator to hold them in place during the long applications which are necessary for the relief required

The clips and cords for transference of the current and holding the electrodes are of importance The cords should be made of flexible or braided wire which will not become angulated and break, because a break in the circuit of a cord will give a very disagreeable shock to a patient Each apparatus should also be provided with one or two bifurcated cords for two attachments to the patient s end so that two electrodes can be connected from one side of the d Arsonval circuit in administering applications to two surfaces from one pole with a large indifferent electrode placed at a definite place to complete the circuit from these surfaces

The clips attached to the end of the connecting cords should be provided with slots, into which may be slipped the edge of the electrodes

for a correct attunement is essential to the delivery of a proper therapeutic current

The spark gap of the resonator is one of the most important essentials to a perfectly working apparatus. The multiple spark gap should be provided with a number of discharging points and a device by which the length of these gaps may be varied, increasing or diminishing the resistance in the patient's circuit (Fig 19) to the requirements of the heat desired and indicated by a hot wire meter in series. The best types of interrupters are those in which the multiple gaps are all opened together, instead of increasing the number or length of the gap. The tips of such interrupters should be made of tungsten, a metal capable of withstanding long usage.

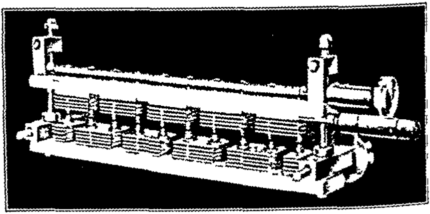

FIG 19—MODERN TYPE OF MULTIPLE SPARK GAP INTERRUPTER REGULATED BY INCREASING THE SPARK LENGTH WITH ALL OF THE GAPS CONSTANTLY IN CIRCUIT

If these gaps discharge in the *open* by a *method* which opens all the gaps at one time the oscillations will be more perfect and uniform than by other methods. Furthermore the wear upon all the tips is the same, and the variations regulated by opening or closing all the gaps is uniform, an improvement over many types of apparatus.

Cross sparkings in the spark gap produce a noisy unharmonious discharge and a lower frequency in point of the oscillations than the gaps described.

The objections to a *closed* gap are (1) that it must be frequently opened and cleaned otherwise the discharge soon becomes imperfect, and (2) those with mica insulating discs often become punctured, requiring that they be replaced.

The capacity of the condensers in the alternating current circuit is varied to give the desired amplitude and frequency. Two to four condensers of one quart capacity, coated, if Leyden jars, within and without over about two thirds of the surface, is the usual arrangement in the

electrodes and effluves, as measures for inducing heat locally, are limited by the surface irritation produced The counterirritant action of the current by these methods induces a very active superficial hyperemia, and the effects are like those of conversive heat, the current passing in and out of the body—at capacity

The technic of the methods for producing *conversive heat radiant light and heat and diathermy* is distinctly variable according to the effects sought

Skin Toleration—In all methods of heat application, there are practical rules of limitation to the degree of heat applied that will vary materially with different methods The skin will stand a greater degree of heat from dry hot air than from any other method of application, and paraffin baths are tolerated at a temperature far greater than warm water The surface is peculiarly sensitive to moist applications or applications that produce moisture that cannot be promptly absorbed or evaporated

Time of Application—With all methods the indication is to alter local conditions requiring as a rule prolonged applications of conversive heat in order that the fixed cells may become well heated, that the cooling influence of the blood stream at normal temperature may not too rapidly restore to normal the heated tissues and limit the duration of the hyperemia, which, for beneficial effects, should persist for a considerable time after the administration.

TECHNIC OF RADIANT LIGHT AND HEAT APPLICATIONS

Position—The position of the patient should, as a rule be reclining and comfortable and the source of the rays should be so placed that the radiations will be projected perpendicularly upon the surface requiring treatment.

Distance—The distance from the reflecting source of light should be adjusted to the comfort of the patient with a degree of heat always verging on discomfort—very warm.

Extent of Exposure—The extent of exposure, as previously stated should be decidedly larger than the area of involvement but should be so limited as not to cause discomfort from relatively heating unnecessarily parts not requiring it This may usually be regulated by the use of a small light apparatus for a small area and larger lamps or applicators over the body and extensive surface regions

Length of Exposure—The time required should be in nearly all conditions, when not otherwise specified, at least one hour for each administration In cases of severe conditions as of *erysipelas* or *abscesses* the one-hour exposures should be frequently repeated or continuous and continued until severe symptoms have subsided

One extremity should consist of an open jaw provided with a screw for clamping it to the electrode. The clips should be capable of being securely held to the electrode, so that it will not become displaced during the process of treatment, when it might severely burn the patient.

Another measure to be provided is a means for securing the electrodes in position, so that a restless or nervous patient cannot remove them during the passage of the current, and so occasion a disagreeable burn from a small contact during the treatment by an attempt to remove the electrode when a current is passing. Pads with straps and buckles or bandages, which can be secured by the operator, are suitable devices for securing the electrodes in position. Such is a practical precaution against accidents in case of such patients.

Autocondensation.—The autocondensation couch or chair is one of the perquisites of thermic treatment. The couch or chair (Fig. 90) should be of such length that the patient's body and extremities can be placed in a field opposed to a sheet of metal or wire mesh measuring approximately sixteen inches in width by sixty inches in length and provided with a socket for connecting one pole of the d'Arsonval terminal to the sheet of metal. Over this should be placed a felt or silk lined cushion, approximately three inches in thickness and six inches wider and longer than the sheet of metal. The cushion may be covered with leather, cloth material, or pantasote. Upon this the patient should recline during the administration of the autocondensation current, and it may be employed either for administering the treatment for hypertension, or in the indirect d'Arsonval method of treatment for heat therapy to be described.

A large solenoid for autoconduction treatment, as devised by d'Arsonval, should be approximately two and one-half to three feet in diameter and six feet in height when extended, and consists of a spiral coil of wire, the opposite extremities of which are connected to the opposite terminals of the d'Arsonval solenoid. This apparatus is not often used in this country and would be rarely called for, because the autocondensation method is far more practical and accomplishes all or more than could be accomplished by the large solenoid.

GENERAL PRINCIPLES OF TECHNIC IN THERMOTHERAPY

Certain general principles apply to all methods of employing heat in therapeutics: (1) the surface treated should always be considerably larger than the parts involved in the pathological process; (2) when stasis is established, heat may increase it, whereas before stasis is established, heat thoroughly applied—preferably by the conversive methods—may prevent it; (3) the effects of the high frequency vacuum and non vacuum

weak, irregular or thready pulse Preexisting cyanosis gradually disappears

"In from ten to thirty minutes after the beginning of treatment, and dependent chiefly upon his reflexes the patient's pulse becomes softer, when previously hard Rather quickly there is established a distinct sensation of a full, soft, rolling pulse often with prolonged diastolic and full systolic periods apparently in part due to the diversion of the blood to the arterioles, whose elasticity is increased by the heat but also to neuromuscular stimulation The quality of the pulse is characteristic once one is familiar with it.

"If, however, the body has been exposed to a temperature much lower than 400° F no such effect occurs but after a considerable length of time, there is, instead of stimulation an actual depression, accompanied by mental inactivity and a general sense of laxity proportionate to the length of time the patient is exposed to the heat Such effect from slow and low heat application neutralizes all attempts at producing reflex stimulation, later by rapid and high temperature applications

"Under these latter incorrect conditions a patient suffering from cardiac dilatation or toxicity shows little tendency towards improvement in the quality of pulse at any time and if long continued there is still further evidence of depression and increasing cyanosis"

In order to note the heat effect produced upon the deep glandular areas Dr Price has found that it was necessary to continue the heat application until the peak of nervous stimulation has been passed with a tendency to drowsiness else the patient is left in an uncomfortably over stimulated nervous state without the full accomplishment of the main object glandular stimulation This period also corresponds with that of the fully developed and characteristic pulse quality

"The patient's temperature is no index to sufficient dosage, and, if it were an accurate reading could not be obtained by mouth because of the cold applications Even the rectal temperature does not increase much over 2 F under usual conditions Therefore the result obtained is impossible of explanation from the penetration of heat It is a reflex result

During this time the patient is always kept incased in Turkish toweling and cold applications applied locally to the head The room should be kept at a temperature not lower than 75° F for a period of five to fifteen minutes during which time the water temperature is lowered somewhat.

"Immediately upon the establishment of a complete reaction the patient should be transferred from the oven table to the lowering device which is in readiness over the bathtub full of water beside the oven table This water must be at a temperature of from 107° F to 109° F, depending upon the patient.

Large Applicators—Large applicators with multiple lights within a reflecting surface are used for their tonic and constitutional effects, and the treatment should not be continued until they cause a feeling of exhaustion. One-half hour applications are, as a rule, sufficient.

Light Baths—These baths should be administered, except in sturdy individuals, with the patient in a reclining position and followed by a considerable period of rest after the administration. The temperature of the bath should be such as not to cause discomfort to the patient and the time ordinarily not longer than twenty minutes.

TECHNIC OF THE OVEN BATH

No treatment should be administered during the period of active digestion or while under excitement. The room in which the treatment is given should be well ventilated and should be at a comfortable temperature at the time when the patient is being transferred, when all draughts must be avoided.

The administration should take place with the patient lying in position upon the oven table. The oven table should be perforated and provided with a mattress about one inch in thickness for the comfort of the patient, and to protect against burning. The patient should be covered with three thicknesses of Turkish toweling tucked in around the extremities or *angular parts of the body. Additional thicknesses of toweling* should be applied over the feet and legs, and, if the patient is corpulent, another thickness over the abdomen. These wrappings should be without folds and applied without undue pressure anywhere, and the bath sheet should be tucked in under the mattress edge, otherwise some of the heat will escape. The oven table is then pushed into the oven and the heat retaining curtain is placed around the patient's neck and shoulders, in order that the hot air may not escape. The gas is then lighted and the oven temperature should rise to from 400° to 450° F within four minutes. A lower oven temperature and less covering does not give the same result. During the administration and also after being placed in bed, the patient's head must be constantly cooled with frequent local applications of cold damp cloths.

When the body is exposed to high temperatures and the head is kept cooled, a secondary dilatation of the intracranial vessels will be prevented and the following evidence of the reflex effect will be produced:

"Shortly there is a marked reflex stimulation [in every case]. This state of stimulation is accompanied by mental exhilaration and clarity of thought. The pulse becomes slower, fuller, and relatively strong in cases of cardiac dilatation or toxicity in which there was previously a rapid,

Local Hot air Baths—The local hot air bath is indicated for the treatment of local septic infection in an arm or leg where stasis and edema are not too marked or where pus, if present in the subcutaneous tissues has been evacuated The parts should be wrapped in at least three or four thicknesses of Turkish toweling and placed in a small oven designed for the purpose, upon the suspension device provided in the apparatus, and with the heat retaining curtain carefully adjusted so that no heat will escape, the heat is then turned on

TECHNIC FOR ADMINISTERING HYDROTHERAPY

The technic for administering hydrotherapy according to Baruch is as follows

The Wet Pack— Two *large* woolen blankets are spread upon a mattress most appropriately placed (a rubber sheet must intervene to protect it from the moisture) upon a high four legged cot Upon this is spread smoothly a linen sheet, wrung out of water of temperature 60° to 70 F, appropriate to the case the blanket should be long enough to extend a foot or more beyond the patient s extremities The patient is placed upon the sheet with his arms raised alongside the head One-third of the sheet is drawn from left to right across the chest The arms are lowered alongside the body and the other two-thirds of the sheet are brought across the body, covering both arms but leaving the latter separated from the trunk by the intervening sheet The lower part of the latter is pressed between the thighs and legs and the lower border tucked under the heels The upper border of the blanket is now grasped with the right hand, drawn at right angles to the clavicle downward, the fingers of the left hand are placed about fifteen inches from the clavicle against the border of this tightly drawn portion and held there while the right hand draws and pushes the latter across the chest over the clavicle and shoulder beneath which it is tucked This procedure is similar to reversing a bandage Then on both sides the blanket is brought over the body and tightly tucked under it then drawing with the left hand upon the portion of the blanket or sheet covering the patient, then with the outstretched fingers of the right hand pushing the border of the blanket covering the body beneath the latter along the entire length of the body This procedure is repeated on the other side with the second blanket The lower edge of the blanket is now gathered together and tucked beneath the heels Everything depends upon complete exclusion of air from the blanket cover The patient may now be covered with more woolen blankets if necessary If the covering has been skillfully done the patient will resemble a mummy whose head is enveloped in a wet turban Unless

"After a period of five to fifteen minutes, during which time the water temperature is lowered somewhat, the pulse diminishes slightly in frequency and loses some of the characteristic rolling quality. At this time the patient should be raised out of the water on the tub elevator and, under the Turkish toweling, given a rapid rub with hot salt all over the body. It is imperative to avoid the contact of air currents, even for an instant, as they cause peripheral arterial contact with corresponding splanchnic dilatation."

After the salt rub the patient is again immersed, to wash off the salt, and then raised out of the water and covered with a hot dry bath sheet, replacing the wet one. The patient must always be kept in the prone position, and is not allowed to sit upright for danger of syncope. The blood at this time has been drawn from the interior to the surface, and it may be said in this connection that the skin will contain two-thirds of the blood of the body, for this reason great care should be taken in all the movements of the patient that he be lifted and maintained in a reclining position.

After removal to the table he is thoroughly dried and massaged, and is allowed nothing to eat or drink except hot water, if thirsty, for a period of two or three hours or more, depending upon the condition, during which period he is not allowed to change from a horizontal position or he might suffer an attack of syncope, from the presence of so much blood at the surface.

"After a period of five to seven hours, except where especially contraindicated, the patient may assume his usual course. It is necessary to remain quiet for this period, as such is required for the natural and complete restoration of responsiveness on the part of the heart muscle, as well as that of vasomotor control. In persons with cardiovascular disease there is serious danger in getting around earlier. If such a person rises too early after the treatment, there is splanchnic dilatation in degree depending upon conditions, but in all cases the early assuming of the upright position obviously disturbs the channels of vascular dilatation as produced by the heat, with the consequence that the glandular activity already established is terminated.

"After a properly managed oven bath in cases of submetabolism there is found in the following twenty four hour sample of urine a marked increase in the total solids over the preceding sample, whether the deficiency was in urea or chlorids, elimination arising from acidosis, intestinal toxemia or in the blood retention of sugar. The blood analysis correspondingly shows a diminution in urea chlorids sugar, or acetone bodies. This result is so pronounced that such cases, when apparently hopeless, do revive because of the stimulation of the deep reflexes and the prompt elimination."

The aerator designed by Dr Bardwell differs distinctively in the nozzle, which may be attached to any tank, of which there were and are now many forms employed in the Army Hospitals and in the Veteran's clinics

The apparatus is best made attached to the tank as a permanent fixture with provision for the drain overflow The Leonard mixing valve and air meter should be directly attached to the tank as any two faucets on a sink

This apparatus is used very extensively in the Veteran's Bureau Hospitals throughout the country and serves a useful purpose as one of the measures that are employed for relieving some of the less common painful conditions

THERAPEUTICS OF HEAT

Heat Therapy—This subject embraces a very extensive field of indications It fills a very important role in the treatment of a large range of impaired conditions of function and inflammation There is undoubtedly no measure in medical use that so aptly or completely fills the useful demand for the treatment of *infectious conditions* as the methods of employing convective and conversive heat Likewise, in the treatment of defective metabolism impaired by inflammation and disturbed functions, these measures are used in conjunction with other physical modalities and accomplish results that are not and cannot be obtained by other measures in medical practice

The application of radiant light and heat dry hot air, and diathermy to the treatment of *local infection* as previously stated in explaining the physiological effects of hyperemia acts upon infectious conditions in three distinct ways

1 The application of heat and light is particularly efficacious in destroying certain bacteria *in situ* All bacteria in superficial fields susceptible to light or 106° F of heat may be destroyed by applications of radiant light and heat from incandescent sources In the administration of reflected incandescent light and heat, the limit of the temperature to be employed will depend upon the skin toleration and so also in the cavities of the body conditions that are susceptible to heat as the presence of gonococci yield to applications of diathermy

The skin and tissues as previously stated will readily withstand the ultraviolet rays and all bacteria located in or immediately beneath the surface are destroyed This property renders them invaluable in the treatment of a large range of infectious conditions

2 Another method of effecting the destruction of bacteria is by the institution of active hyperemia through heating of the involved tissues

given for insomnia the patient should receive an affusion at 70° F after removal from the wet pack and go into the open air after being dried

"Modification of this procedure consists in half packs, in which smaller or larger parts of the body are enveloped in the damp sheet The duration of the pack (which should be from one-half to one hour), the texture of the sheet, the temperature of the water and extent of pack, as well as the repetitions, modify the effect materially, as will be seen If given for insomnia, the patient must remain in the pack, if asleep, rapid but gentle drying follows, and the pack must be given in the bed"

Dr Baruch further states "The first effect of contact with the cold, damp sheet is an irritation to the cutaneous nerves, and narrowing of the cutaneous vessels, which continues until the individual's power of reaction comes into play This depends, as in all hydriatic procedures, upon the age and condition of the patient, old people and children do not react as readily as adults, and a previous high temperature of the skin furthers rapid reaction when circulation is not very feeble There being no mechanical aid given by the attendant, as in the sheet bath, reaction depends entirely upon the vital powers of the patient This fact distinguishes the wet pack completely from all other hydriatic procedures, and demands judicious recognition of the patient's reactive capacity As soon as the first "shock" is over, which lasts one to five minutes and sometimes produces shivering, the peripheral vessels begin to dilate, and the system makes an effort to equalize the temperature between the skin and the sheet When the body temperature is high, as in fevers, there is no chilliness, the cooled blood is driven from the surface to the subjacent structures, but very soon the warm blood from the interior takes its place, and dilatation of the vessels is the result This continuous interchange of temperature which occurs easily and slowly in patients with normal temperature, gives rise to a vaporization of the sheet which furthers loss of heat from the skin This is increased by non-conductivity of the blanket He soon experiences a mild heating of the body due to the conservative powers of the organism, continuing to create heat to compensate for the threatened or accomplished loss"

The Whirlpool Bath—This bath, introduced during the Great War for use in the Army, serves as a valuable means of treating open wounds and inflammatory conditions It was found particularly valuable in the treatment of tender stumps The parts should be immersed for a considerable time during each administration

The discharge of water through a one eighth inch opening under pressure as in the Bardwell type of bath (Figs 15 and 16) draws in the air, giving a greater degree of commotion in the tank than did the first apparatus used in the Government Hospitals

silitis within the first twenty four hours confirmed long ago in the writer's experience, is the application of the static wave current with a small metal or surface vacuum electrode placed directly over the enlarged hardened tonsil, which may thus be softened with a complete resolution of the induration before pus There is no danger in the first twenty four hours, before pus, of extending the infection, but the method is effective in resolving the process and aborting the tonsilitis

Felons and Whitlows—When these are treated in the first twenty four hours, they may also be promptly relieved by the static method Long exposures to radiant light and heat should precede the use of the static current in these cases and also in cases of tonsilitis Otherwise felons and whitlows may be treated with ultraviolet rays and incandescent light radiations as outlined in the treatment of boils and furuncles

Acute Otitis Media—Treatment of this disease by radiant light and heat is one of the classical methods in heat therapy that should be universally adopted, and would be but for the inattention manifested by the otologists In the first stage of an otitis media, if radiant light and heat is thoroughly applied for one or two hours to the surface, at a distance at which the patient will tolerate the heat this procedure will often abort the infection at the onset This the author has confirmed in two instances on his own person If, however the condition is not aborted, the relief afforded by the local applications of reflected incandescent light and heat will insure the patient great relief from the intense pain After the pus has begun to discharge, whether a paracentesis is done or not if the light applications are persisted in with two one hour applications on the first day and once or twice daily on subsequent days for at least one hour each time, the trouble will be cured with the membrane repaired within two weeks, and a chronic discharge will not persist

Chronic Purulent Otitis Media—This can be relieved by daily one hour applications of reflected radiant incandescent light, as in the acute cases This treatment will successfully cure most cases in which there is no bone necrosis within three weeks and usually much sooner with a healing of the membrane This method was introduced by Herbert F Pitcher M D, of Haverhill Massachusetts and the writer has observed the results from the method in a large number of cases in none of which it took over three weeks to effect a cure If this statement is doubted a thorough trial and investigation of the method will be convincing

Mastoiditis—Mastoiditis would very rarely occur if otitis media was attended to by the method described It has often been aborted by the method outlined above as reported by Dr Pitcher in his original paper and this method should be recommended in early cases, notwithstanding the attitude of the aurists If pending an operation there was a delay for from ten to fifteen hours a more or less persistent application of reflected light over the involved parts has in many cases caused a dis

By this means the phagocytes are drawn in greater numbers into the infected field, raising the local resistance of the tissues and thereby enabling the phagocytes to destroy the bacteria, and the tissues to throw off the local invaders The altered condition of nutrition, furthermore gives added force to the fixed cells, the macrophages, in the lymphatic system, whereby resistance is fortified against infection and the system is enabled to throw off bacterial invaders

3 Another method of effecting a local process of infection is by the use of the X ray or radium, whereby the bacteria are sterilized and so *rendered inert* *After a requisite series of short exposures, an active* hyperemia is induced, as by the previous method, so carrying away the inert bacteria The success of this method is practically demonstrated in tubercular and pyogenic processes

Treatment of Special Conditions of Infection

Boils —In boils prolonged applications of radiant light and heat, or prolonged applications of the high frequency current from vacuum or non vacuum electrodes, will often abort the process This is accomplished by the induction of active hyperemia and the action of the heat upon the bacteria

Abscesses —Ultraviolet rays have proved very efficacious in curing incipient abscesses when applied through a quartz applicator with com*pression of the offending process* *That such an application may* produce a blister should not forestall a thorough application to the surface, as the blister soon disappears and the germ process as well, when treated before pus The same measure may be effective in aborting *carbuncles* in the first stage before pus is formed The ultraviolet application should be followed promptly on the following day by the application of reflected incandescent rays with long exposures, which will hasten the healing of the blister and further destroy any remaining local infection

Another method which has been successful in the treatment of *car buncles and crops of boils* is the administration of an erythema dose of X rays, followed the next day by a two hour application of reflected radiant incandescent light, and this followed by a thorough application of the high frequency current from vacuum or non vacuum electrodes *There* are three factors which enter into this method (1) thorough *sterilization* —not destruction—of the bacteria by the prolonged application of X rays, (2) *active hyperemia* induced by the radiant light and heat, which carries in a vast number of phagocytes, and (3) tissue resistance and phagocytosis which is still further accentuated by the application to the surface of the current with the high frequency electrodes

Quinsy —This may be relieved by the same methods applied externally over the indurated tonsil Another method of treating suppurative ton

hour is remarkable and the progress to a cure usually complete in a few days

Foreign Bodies —Following removal of a foreign body from the eye the application of reflected light for half an hour will afford prompt relief from the irritation caused by the presence of the foreign body

Erysipelas —There is nothing during recent years that has given the writer greater satisfaction than his own results and those of others from the use of radiant incandescent light in the treatment of erysipelas The discovery of its efficacy was made by the writer more than ten years ago when a patient came into the office with a well-developed erysipelas of the face in the first stage The light was reflected upon the surface for one and one-half hours and the relief was complete, as the condition made no further progress This led to a question as to the diagnosis, but when light was applied later in a very striking and marked case, the same result was obtained with a complete cure of the condition within two days It was thus demonstrated that erysipelas can be cured by this method, and this has been repeatedly verified

Local Septic Infection —Local septic infection or blood poisoning has destroyed the lives of many physicians and surgeons, and frequent reports of fatalities establish the condition as a matter of so great concern that the management of these cases by *heat therapy* must be considered at length, because we believe it to embrace methods of great importance in an otherwise unfortunate class of conditions

When following an accident or operation the surgeon discovers a point of infection or upon a patient a painful spot appears having the characteristic indication of septic infection, the early application of the ultraviolet rays over the site followed by a long application of reflected incandescent light and heat will in nearly all instances abort the trouble In the absence of a mercury vapor lamp there are few cases that will not yield to prolonged applications of incandescent radiations from the small therapeutic lamp at this early stage When however, the infection has become seated in the hand or leg and lymphangitis appears the seriousness of the condition will be confirmed That there is no difficulty in controlling the infection at this stage, either by prolonged applications of radiant light and heat or by the ultraviolet rays either in cases of this kind, or in any case in which pus has not accumulated, is an established fact

In septic cases which have been opened and drained but in which from peripheral indications extension to the trunk is to be apprehended, the administration of dry hot-air in the localized oven for treating arms or legs promises prompt relief With the parts well wrapped in three or four thicknesses of Turkish toweling and enclosed in the oven employing a temperature of from 400 F to 500° F for one hour daily the heat will promptly relieve and cure the condition in three or four days This

tinct fall in the leukocyte count, indicating that operation was unnecessary. Numerous cases of mastoiditis have already been reported as having been cured by daring men who were willing to take a chance in the face of surgical criticism. There is abundant evidence of the wisdom of such a course. We believe that every effort should be made to bring the otologist to recognize the importance of employing, in the treatment of otitis media, a measure so safe and so certain of success. When this is done, mastoiditis will be a rare condition.

Coryza.—A simple coryza, affecting the mucous membrane of the nares, is relieved with remarkable promptness by repeated one-hour applications of reflected incandescent light, employing the smaller lamp. These applications should be made morning and evening, with the lamp suspended at a distance that can easily be tolerated by the skin, so as not to cause the patient undue discomfort. If desired, a small pledget of moistened cotton may be put over each eye, but there is no harm from the exposure, if the eyes are kept closed during the application. If administered morning and evening, rarely more than three or four applications will be required completely to relieve the coryza. The same measure applied to a throat affected with laryngitis will afford relief. The effect, however, is not so uniformly successful as with coryza, but promptly yields to diathermy.

Sinusitis.—When this is treated by the same method as coryza it will require a greater number of applications, but in most cases can be completely relieved within one month, varying with the condition—acute or chronic. This has been a routine practice in the offices of the writer for the past fifteen years, and the results have been so uniformly successful that he can speak in the highest terms of the results.

Another beneficial method in these cases is the use of diathermy with the active electrode placed over the forehead and sinuses and the indifferent one upon the back of the neck. The active electrode should be about two inches in width and six inches long. The relief from discomfort is often instantaneous.

Suppurative Conditions.—In suppurative conditions of the antrum the persistent use of light, after the cavity has been drained through an *opening into the nares*, can be depended upon to dispel the condition which would, otherwise, be persistent. To relieve this condition either in sinusitis or in antral abscesses will require several weeks of daily use of the radiant incandescent light.

Purulent Conjunctivitis.—In purulent conjunctivitis of pyogenic and gonorrheal origin the radiant incandescent light is remarkably effective in conferring relief. It is, undoubtedly, the heat in these cases that effects the destruction of the bacterial process. From the institution of the treatment applications should be made of one hour in duration each followed by a two hour interval. The relief from pain in the first half

said to the writer that he had tried the next case, with success, and that he now employs it as a routine method not only in infections, but before and after operations

It will be seen by these reports that, even in serious and neglected cases the measures are successful, so long as a serious destruction of the parts or adhesion of tendons in their sheaths has not yet become assured

There is no subject among those here treated for which the author asks a more conscientious sympathetic investigation of the statements made than in septic cases since thereby fatalities can be curtailed and the number of disabled and crippled limbs can be reduced

Indurated Acne —This class of condition is not as a rule successfully treated by the usual dermatological methods During the past twenty years very many young men and women have come to the office of the writer and his wife and associate Dr Mary Arnold Snow, with their faces scarred and in varying degrees covered with large heavy acne pustules The practice of treating these cases by puncture curettage and antiseptic injections has been of little avail in lieu of what we believe to be the curative method of choice—the X ray We wish to emphasize here the importance of employing other methods with this

If following the last X ray exposure there are still a few persistent pustules a small number of applications of the vacuum electrode preferably employing the static current but otherwise with the high frequency apparatus thoroughly applied over the face will leave the skin free and clear of the infection

It may prove possible though in the writer's experience this has not been demonstrated to cure indurated acne with repeated applications of the *ultraviolet rays*

The difficulty in *furuncles and crops of boils* is that the extension of the infection takes place through the lymphatics under the surface of the skin and that the processes crop up like weeds in the garden from a preceding infection, which the ultraviolet ray may not penetrate deep enough to forestall as the X ray does It is probable that persistent applications of the glass electrode currents or of reflected incandescent light would be more effective in these cases than the ultraviolet ray The X ray has filled the rôle in the writer's experience without a failure in a very large number of cases, at least fifty and he cordially endorses the method

In simple acne the chief indication is to produce contraction of the outer layer of the skin and so close the mouths of the sebaceous follicles against admission of foreign substance and consequent black heads and suppuration It is in the relaxed porous skin of the young man or woman at puberty that this condition generally occurs and the presence of these blemishes is a source of great annoyance to those so marked One series of X ray exposures will usually suffice to effect a cure This has been verified in the experience of numerous writers

statement is based upon personal experience with a large number of cases without a failure

The following case reports will illustrate the method in serious cases under varying conditions There are so many failures under the present practice of applying hot wet dressings and the knife, and so many of these cases occur, as to lead the writer to urge the investigation of the methods outlined

Case 1 Mr S referred by a local physician came under observation after numerous openings had been made draining the pus from the subcutaneous tissues of the arm and forearm The arm was wrapped in Turkish toweling and placed in the local oven apparatus (Fig 1°), according to the technic elsewhere described The treatment was given, as is customary, for from thirty to forty minutes with a temperature of 400° F After this application the arm was dressed and bandaged, and the treatment was repeated on the following day and again on the third day After these three administrations there was no further evidence of infection and the parts healed promptly without further treatment

Case 2 A local physician who had infected his right hand at an operation came with a distinct swelling in the hand and forearm with no evidence of fluctuation or the presence of pus, but with a lymphangitis extending up the arm to the axilla, indicating that the infection was well advanced The part was subjected to the same treatment as the preceding case, and only three treatments were necessary to remove the infection As a rule this is the ordinary routine before pus is formed in the subcutaneous tissues

Case 3 The third case represented a condition that had been neglected for three months following the infection When the case came under observation there were three sinuses discharging pus on the back of the right hand The joints were stiff and the hand useless The end of the index finger was sloughing to the bone The examination demonstrated that the tendons were not bound in the sheaths A good prognosis was given, much to the surprise of the surgeon We instituted the dry hot air oven treatment which was administered five times and in the interval long applications of reflected incandescent light were made, and the forearm and hand were exercised and vibrated between treatments The parts gradually became flexible, the sinuses closed, and the ulceration at the end of the index finger healed promptly within three weeks The patient was able to return home with a useful hand

In an interview with Dr Ochsner in Chicago, in the summer of 1911 he related his experience with an infection in his own arm, from which he had been suffering severely when one of the young men on his staff suggested radiant incandescent light As a matter of fact the Doctor did not have much faith in the measure, but he said, 'Try anything" The condition was promptly relieved and he was soon cured Still skeptical he

said to the writer that he had tried the next case with success and that he now employs it as a routine method not only in infections but before and after operations

It will be seen by these reports that, even in serious and neglected cases, the measures are successful, so long as a serious destruction of the parts or adhesion of tendons in their sheaths has not yet become assured

There is no subject among those here treated for which the author asks a more conscientious sympathetic investigation of the statements made than in septic cases, since thereby fatalities can be curtailed and the number of disabled and crippled limbs can be reduced

Indurated Acne—This class of condition is not as a rule successfully treated by the usual dermatological methods During the past twenty years very many young men and women have come to the office of the writer and his wife and associate Dr Mary Arnold Snow, with their faces scarred and in varying degrees covered with large heavy acne pustules The practice of treating these cases by puncture curettage and antiseptic injections has been of little avail in lieu of what we believe to be the curative method of choice—the X ray We wish to emphasize here the importance of employing other methods with this

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Fungus Infections of Skin and Scalp.—In these conditions, including tinea tonsurans, favus, and sycosis, the X ray has long held an unquestioned reputation as a curative measure. There is, however, no doubt that radiant light and heat and the ultraviolet rays, particularly the latter, will prove capable of destroying the fungi of these conditions. If the ultraviolet rays are employed, a blister should be induced at each exposure, and this course should be persisted in. The exposures or applications should be made by passing the rays through a quartz applicator and applying them with pressure over the affected areas.

Urticaria and Hives.—These affections usually arise from a disturbed gastro-intestinal tract, often due to idiosyncrasy to some food, and may *persist after removal of the cause. They may then be promptly relieved by* long exposures to incandescent light radiations.

Treatment of Pulmonary Conditions.—In the treatment of pulmonary affections occurring at various sites, there are probably no measures more energetic or successful in limiting the process and relieving the condition than the administration of radiant energy and diathermy, particularly the latter. In the incipient stage of pulmonary tuberculosis, before there is danger from hemorrhage, hyperemia induced throughout the lung substance by high frequency diathermy offers much through arrestment of the process by the local destruction of bacteria on the part of the lymphocytes. The X ray has been demonstrated to increase local lymphocytosis and is indicated in conjunction with other measures. These measures offer much in relieving the incipient stage of pulmonary tuberculosis, with the corrections of habits, or of digestive disturbance or other functional derangements which have lowered the patient's resistance.

In acute pleurisy there is probably no other measure that will give so prompt and complete relief as diathermy, employing two large metal electrodes, usually placed laterally on the opposite sides over the lungs, directly opposite. The pain and fever disappear as a rule with the first treatment, which should be applied with as high a temperature as the skin will permit. According to the writer's experience the duration should be for one hour at the first sitting, and the patient should have the wearing apparel all removed and be either wrapped in a sheet or in a kimono *or pajamas. This precaution is taken in the treatment of all cases in* which the high frequency current is employed over large surfaces in order that the clothing may not become moistened by the general perspiration induced, and so endanger the patient to a future chill from exposure after leaving the offices.

Bronchitis. Acute and Chronic.—*Acute.*—Acute bronchitis should be treated in practically the same manner as pleurisy, the electrodes, however, being placed anteriorly and posteriorly instead of laterally. The same rules as to dosage and precautions against dampness of the clothing and thorough drying of the patient before dressing should be observed.

The electrodes in these cases should be approximately twelve inches square When there is a *complicating laryngitis* the anterior electrode may have attached to it another small electrode placed over the larynx during the administration There are few cases of *acute* bronchitis that cannot be effectively cured in two or three such administrations There is no more gratifying result obtained by any other method in any condition than by diathermy in the treatment of acute bronchitis

Chronic—In chronic bronchitis three or four weeks may be required to effect absolute relief of the condition Treatments should be given at first daily and continued on alternate days until the chronic cough has completely disappeared It is rarely necessary in the treatment of these cases to administer expectorants as the relief is so prompt and progressive that these nauseating and depressing measures may be avoided

Pneumonia—It has been anticipated from the results obtained in the treatment of *pleurisy* and *bronchitis* that pneumonia would naturally be relieved and possibly cured by the same measures Clinicians familiar with the indications for the use of *radiant light and heat* have frequently shown that pneumonia patients are relieved from cardiac weakness with control of temperatures and increased elimination by prolonged applications of this remedy The value of reflected incandescent light in pneumonia has often been confirmed Even if not employed throughout the whole course, the effects are most gratifying at the time nearing the crisis, with indications of cardiac failure and with a weak irregular pulse

The following case will illustrate the point of view

A physician called the writer in consultation concerning the condition of his father an aged man who was suffering at the period of crisis with delirium The pulse was weak and intermittent and the prognosis serious Prolonged applications of reflected incandescent light were advised over the chest and body employing a multiple light applicator The result was highly gratifying Immediately the force of the pulse increased and the beats became regular the respirations became deeper the delirium disappeared and the patient made a prompt recovery

This was in accord with the principles set forth in the previous part of this chapter, where the effect of peripheral heat applications upon the deep spinal reflexes is referred to as affecting cardiac and pulmonary centers

There is no danger, whatever from such an administration and reflex response of the vital centers to peripheral stimulation may be relied upon as other stimulants cannot be with the same confidence

Reported success from the employment of *diathermy* in all stages of pneumonia has opened up in a most striking way the indications for its rational employment It seems from the reports that, at any stage of the infection, improvement is instituted from the first administration It is possible that when the first severe pleuritic pains and the chill mark the onset if diathermy is at once administered throughout the

involved portion of the lung, the condition may be promptly aborted as occurs in all cases of pleurisy that are treated at the onset The increased influx of arterial blood to the lungs carries along a multitude of phagocytes, which may prove capable of cleaning out the bacteria from the lymph spaces, as they do in bronchitis, so aborting the process at the outset Cases of severe pleurisy are promptly arrested and we believe that pneumonia may be in the first stages

It is only fair to presume that this would occur after the results obtained in the treatment of advanced cases Nine cases were reported by Dr Harry Eaton Stewart of New Haven Connecticut, which were treated at the Marine Hospital on Staten Island under his direction In every instance lysis was instituted at the first administration of diathermy, the current being employed for not longer than one half hour, and recovery was complete in every one of the cases so treated, except one, a tenth case, in which there were complicating conditions In this case the findings at autopsy were "Lobar pneumonia on the right, central pneumonia on the left, pleurisy with effusions on the left septicemia in the pleural cavity and an exudate about one-eighth inch thick, which covered the pleura"

The following are Dr Stewart s conclusions

"The results in these cases are suggestive that diathermy will have a marked influence in hastening recovery in pneumonia The evidence is not at all conclusive In several of the cases the diathermy was not instituted until the time when in favorable cases the temperature might be expected to start downward, but it is the opinion of the medical staff who selected these as test cases that diathermy helped in their recovery When we have had many more cases to report on, we hope to be able to make a more definite statement, but this much we do know, that, with *every single case* and in *almost every single treatment* the temporary effect upon the patients was remarkable Cyanosis disappeared The expiratory grunt, when present, was markedly lessened or stopped entirely respirations were less labored and the patient received from two to four hours of very marked relief, in many cases obtaining sound sleep Now diathermy has been ordered as soon as the diagnosis is made in every case of pneumonia at the Marine Hospital"

In the future, treatment of these cases may be administered at the bedside in the hospital or in the patient s home by the installation of portable apparatus wherever the electric current is found

Numerous manufacturers are making portable high frequency apparatus which can be brought to the bedside when if the current is administered by competent physicians who understand the technic, there can be no question as to the expediency of treating cases of pneumonia in

hospitals with diathermy, as may also be done with cases of pleurisy and bronchitis

Cholecystitis —In catarrhal cholecystitis the administration of diathermy through the gall bladder affords prompt relief from pain and tenderness over the region, and in acute cases promptly restores the normal circulation with relief of the process In chronic cases relief will be relative to conditions In cholecystitis as in all conditions of infection, the presence of pus contra indicates the use of diathermy

Catarrhal Appendicitis —The same may be said of the treatment of the early stage of appendicitis before the development of pus It is possible in these cases properly to dissipate the local infection relieving the pain and muscular tension by either diathermy or radiant light and heat deferring recourse to surgery

Dietitians are contending that all of these pending cases may be saved from operation by the institution of a properly constituted diet—one free from excess of animal protein and consisting largely of whole-grain cereals, whole-wheat bread green vegetables, and fruit

The joint employment therefore of the measures referred to will arrest the process in the early stages and if used conjointly with the establishment of a correct dietary may restore the normal condition

Conditions due to the consumption of various stimulants and narcotics as alcohol and opium which impair the secretions and irritate the conditions of various organs particularly of the stomach liver, and cardia variously disturb metabolism requiring special consideration

The Liver —In cases of acute hepatitis when the leukocyte count will determine that an abscess is not complicating the trouble diathermy passing the current through the liver with one electrode placed well over that organ and the other obliquely on the opposite side of the trunk will arrest an acute condition here as elsewhere In lieu of diathermy long applications of radiant light and heat for periods of two or more hours as in cholecystitis will often afford relief, though not so marked or beneficial as by diathermy

In the atrophic stage of cirrhosis of the liver so called nutmeg liver' with ascites or in the later stages with general anasarca diathermy sometimes accomplishes good results

The following case report will give a clearer understanding of the benefits to be derived from diathermy in this condition

Dr S who had been suffering for several months with general anasarca with marked ascites came under the writer s observation in this condition He was able to get around and to come and go from the office but had given up his active work with the Board of Health and other activities in which he was engaged Diathermy was administered daily for one hour with one large electrode placed over the liver and the other, of equal size, obliquely on the opposite side of the body After two

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(Figs 8 and 9) much relief can be obtained The static wave current would accomplish more in these cases but at the present time it is impossible to employ it at the bedside In the future, however, hospitals will have these necessary facilities for administering all physical modalities with men trained in their employment

Body Oven —The body oven induces three important effects all indicated in kidney lesions (1) elimination by perspiration (2) drawing the blood into the skin at the surface thus relieving local congestions and (3) stimulating the cardiovascular centers from the periphery and thus increasing the cardiac force Body heat administrations, therefore will accomplish much for the relief of the kidney congestion.

Uremic Conditions —When possible to administer the body hot air treatment employing the method outlined under dry hot air technic it is remarkably effective Often when a patient is in the state of uremic coma, relief may follow and the patient emerge from the coma, and a re-establishing of the kidney function may result

Pelvic Conditions —Pelvic conditions, affecting either the male or the female arise from a disturbance of circulation due to infection or other causes In these conditions conversive heat plays an important role as also does convective heat applied with douches for local applications of heat These latter have long held a valuable place in the therapeutics of pelvic disturbances

In infectious conditions of the pelvic organs the use of diathermy applied according to the parts affected using judgment in the placing of the electrodes, promises relief The other methods of heat application are not so effective, because the heat cannot be applied with sufficient energy and direction to destroy the gonococci which will rarely stand a temperature above 104 F

There have been published cases in which a course of fever lasting for two or three days with a temperature of 104 F has been followed by the disappearance of an acute gonorrheal infection

The instituted use of diathermy and radiant incandescent rays has led to an understanding of the prognosis for the use of heat therapy as stated in the pages on technic. It is possible to administer in the interior cavities, temperatures as high as 115° F without danger to the tissues as elsewhere stated by making the area of the interior electrode one-third the size of the electrodes applied to the surface With electrodes having these proportions the operator is able to use a temperature of 11 , F in the cavities of the body

Specific Vesiculitis —In the treatment of specific vesiculitis by employing electrodes placed against the vesicles and prostate it is possible to convey the heat through the parts with a temperature theoretically adequate to destroy the bacteria The applications should be made daily for one hour followed by the static wave current to force out the contents

weeks' administration the improvement was marked and the ascites was much diminished, and within three weeks his circumference was reduced from a highly distended abdomen to normal and his general health was so improved that after four weeks he was able to resume his usual routine duties This was the third case of atrophic liver, associated with cirrhosis, treated with diathermy with correction of ascites to be recorded, the first two having been reported in a paper read before the Greater New York Society by Dr J H Branth of New York

It is evident that the hyperemia induced by diathermy relieves the ascites This method is associated with absolutely no danger to the patient, and should be given a routine trial for though the number of cases reported as treated in this manner are few, the result has been a cessation of the ascites in each case

Stomach and Duodenum—In *atonic conditions* of the stomach and duodenum diathermy will play a most important role in increasing the circulation and restoring the normal secretion Hypochlorhydria is usually associated with a lowered condition of the general system with either anemia or impairment of the conditions and functions of the splanchnic area The indications for diathermy or reflected incandescent light are twofold (1) to improve the circulation in parts showing impairment of function, and (2) to improve the general condition of the blood and so improve the functions If a venous stasis is present in the splanchnic area or in cases in which there is ulceration, in the stomach or duodenum diathermy is contra indicated in the first condition until the disparity is corrected and on account of the danger of hemorrhage that might be so caused when ulcers are present The ultraviolet rays and the X rays offer much for the relief of ulcerated conditions of these parts

Nephritis—In nephritis the indications depend upon the type of conditions In *chronic* nephritis with the presence of albumin and hyaline and granular casts in the urine, as associated with hypertension in progressive arteriosclerosis, diathermy offers much for the improvement of the circulatory condition The electrodes should be approximately six by eight inches in dimension and one should be placed over the kidneys and the other opposite in front The current should be administered from one-half to three fourths of an hour daily at first, and less often as conditions improve This method will accomplish much toward improving the conditions of the kidney

In *acute parenchymatous* nephritis it may often be a *question* as to whether diathermy will be adequate in overcoming the extreme congestion which may be engorging the kidney If a marked degree of stasis is present, it will not be relieved by heat, which increases, without tending to decrease the engorgement Upon administrations in the body oven of dry hot air, alternating with prolonged applications at the bedside of reflected incandescent light radiations applied with the canopy lamps

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of the vesicles The conjoint use of the X ray in these cases is undoubtedly an added means of getting rid of the bacteria, which with a thorough technic will effect a favorable result

Gonorrheal Arthritis—It has been *demonstrated for a long time* that gonorrheal arthritis will yield to the combined methods of static and diathermy The high frequency current may be administered either with the vacuum or non vacuum electrodes or metal electrodes against the prostate and vesicles If the infection is superficial, the high frequency current administered through glass electrodes is effective in the pelvic cavities, and this may be applied with the same general rule as to intensity with the metal electrodes When the infection is relieved, the arthritis will respond to the usual arthritic treatment

The *application of heated metals or irrigations* which has been variously recommended for administration to the prostate gland for treatment of prostatitis, possesses very little relative value, owing to the fact that convective heat is not effective in influencing conditions except superficially The hot water injections are being administered by physicians who are not familiar with the use of electricity, or the effects of heat variously applied, and so do not understand how superficial, and of how little avail, hot water irrigations are, whereas, diathermy heat may be applied at temperatures that will be more effective, because the heat is produced in the affected part, not *around* it When stasis is established in a part, however, diathermy is not so effective in reducing the inflammation as the static wave current which does effect the removal of the infiltration and exudation

Dysmenorrhea—The application of diathermy has been reported by Dr Turrell to possess merit in these cases by passing the current with one electrode placed over the sacrum and the other above the pubis If diathermy is used, a better method is to place one electrode in the rectum and the other over the pubis This method is not so effective as that with the static wave current with metal electrodes placed in the rectum as described under the treatment of prostatitis By this method the infiltration and exudation is removed and the cervical spasm relieved

Subinvolution—In subinvolution the same is true as in the treatment of dysmenorrhea Heat may accomplish some relief, but not nearly so much as the static current applied as stated

Amenorrhea—There is no question as to the indication for diathermy in amenorrhea, passing the current through the pelvis with one electrode over the sacrum and the other over the iliac regions In lieu of diathermy, radiant light and heat may be of great value in these cases

Uterine Hemorrhage—In cases of uterine hemorrhage, there will be nothing accomplished with the thermic methods, but here the X ray and static wave current will meet the indications

Salpingitis—Treatment should be given using the vacuum or non vacuum vaginal electrode in the vagina with the other electrode placed above the pubis, using diathermy as outlined in the treatment of vesiculitis The same method can be employed in treating early cases of pyosalpinx

Ovaritis—This is usually associated with some conditions affecting the uterus, and local applications of conversive-heat may give great temporary relief from pain, but lasting relief should come from the cure of the uterine condition The use of diathermy will do much toward relieving this painful affection but the static wave current is the method of choice applied with the electrode placed against the uterus at the rectal site which will relieve the venous stasis or congestion and give prompt and complete relief in most cases

Hot vaginal douches which have occupied a recognized place for many years, as introduced by Dr Robert Emmett are of undoubted value in mild pelvic conditions however with convective-heat effect only Douches when employed should be given with the patient upon the back with a proper douche pan and the hips elevated It should be administered with a temperature of 108° F to 110° F and for at least one half hour—in order to relieve local congestion Hot douches do not produce so marked an effect as is obtained by conversive heat with diathermy

Non infective Local Conditions—In the treatment of local conditions of non infective origin *diathermy* plays an important part if applied in the early stages

Neuritis—This may be relieved within the first twenty four hours and sometimes later by the application of diathermy and radiant light and heat

Sprains—In the very early treatment of sprains diathermy and radiant incandescent light may be effective in relieving the local condition, but not as a rule Here the static current alone is the indicated method

Contusions or Bruises—The same measure as described above will be found to be effective in relieving these conditions

Fractures—In the treatment of fractures the use of radiant light applications made daily with one of the splints removed so that the light can affect the part will greatly relieve the pain and hasten repair The open treatment and applications of light with extension play an important role in the treatment of Colles fracture The period of repair may be so shortened that convalescence often occurs in less than four weeks

Extensive Burns—Burns upon the body are very much benefited by the use of reflected radiant light and heat The treatment for the first half hour is very painful and the patient will recoil from it and say that it is making him worse but if persisted in he will later make no further protests This has been demonstrated in the treatment of children in Bellevue Hospital There was at first some controversy between

the staff and aides concerning the use of radiant energy, but it has finally been established as a routine method and many lives have been saved and sufferers made more comfortable by the established application of reflected light followed by soft dressings to protect the parts The light should be given with prolonged applications twice daily for at least one hour Repair is prompt, as the increased circulation in the true skin brings about a very active improvement, healing as a rule without scarring

Gangrene—In senile gangrene affecting the extremities, it is remarkable what relief can be afforded in many cases by long applications of reflected incandescent light, persisted in until the parts often heal over

Endarteritis Obliterans—The pathology of this condition is obscure, but the results from the employment of diathermy and radiant light and heat have been very successful The administrations of reflected light should be given with long exposures with the applications made over both extremities, including the parts above the knees When diathermy is employed, the better way is by the method described in the section on Technic, immersing the feet in water, resting upon an electrode in one-half inch depth of a salt solution and the other electrode over the sacrum In this way it is possible to pass the current upward through the limb and all of the structures in the path of the current Either this method may be employed or the cuff method by placing electrodes around the ankles and the other over the sacrum, using a bifurcated cord attached from one side of the d Arsonval to the two ankle electrodes This method is contraindicated if the effect is to be general

Erythromelalgia—Some temporary relief can be derived from the application of heat and diathermy in these distressing cases, but in the writer's experience it is impossible to give lasting or permanent relief to these unfortunate sufferers

Myocarditis—The employment of diathermy through the heart for myocarditis has shown remarkable results as verified by electrocardiograms The current is applied with one electrode placed over the scapula, posteriorly, and the other electrode over the cardia in front The electrodes should be about six inches square, and the current used with a moderate degree of heat, not as great as in the treatment of other thoracic conditions The treatments should be given daily at first for one-half hour, and then on alternate days

Desiccation or Endothermy—This method for the treatment of local, malignant, and other conditions, as introduced and developed by Dr William L Clark of Philadelphia and later by Dr Wyeth of New York, is of unusual value for the treatment of local affections of the skin, mucous cavities, tonsils and hemorrhoids

Apparatus, as described elsewhere, must deliver from the one pole Oudin terminal, under perfect control what has been described as a *cold spark* in other words, a fine spark of such quality that when applied to

paper it will perforate the paper without giving any evidence of burning or charring it In other words it will not ignite burn, or char but perforate the paper This quality of spark is of small amperage and produces a distinct desiccation or drying removing fluids from the skin, and was so termed by Dr Clark for that reason

The tissues treated by this method if applied to the extent of producing complete removal of all fluids are practically killed

When this quality of spark is applied over a small keratosis of the skin, the dried tissue may be removed by the curet, leaving a smooth underlying skin

It is employed with a very short spark to remove keratoses, warts and moles The application may not affect the cutis vera unless so desired except in its outer layer and from the nature of the effect causes drying without bleeding When however it is desired to destroy malignant growth of varying thickness or depth, such as epitheliomas the current must be applied with sufficient energy to destroy the growth beyond the diseased tissues otherwise there will be a prompt recurrence and a more rapid growth than before

In treating such a condition it is customary to go well around the outside of the malignant tissues at the outset After destroying a circle beyond the growth including the deeper layer of the skin, the growth is then attacked directly The operation, except in extensive growths, may be done under local anesthesia In small superficial areas there is usually so little pain or discomfort that an anesthetic is not necessary

The question always arises as to what method to employ in the treatment of an epithelioma on the surface With the X ray or radium properly employed it is possible to remove epitheliomas and rodent ulcers without producing any scarring or evidence of the former presence of the growth When removed by the desiccation method there may be a slight scarring following the recovery

When an epithelioma is situated where some important structure such as the tear-duct, would be destroyed by the desiccation method, the X ray is the method of choice for as has been shown, epitheliomas have been cured by the application of the X ray in the inner canthus of the eye involving a tear duct which has been obstructed and was restored after the X ray had cured the growth showing the remarkable selection of diseased tissues leaving the normal tissues intact If desiccation had been employed under these conditions the canal would have been destroyed

The *applications* with endothermy should be made deep enough to get to the bottom of the involvement It is customary to put the needle carrying the current in and out of the mass moving it about until the diseased tissues are entirely destroyed If extensive and deep cut away the desiccated tissues with curved scissors and then apply the current to the deeper structures, insuring the removal of all of the diseased cells

It is possible by this thorough method to destroy all of the malignant tissues to considerable depths, as has been shown by Dr Clark. Thus not only are the soft structures destroyed, but diseased bone as well. In the case of bone, however, the area treated will later separate as a sequestrum or may be curetted or chiseled away at the time of operation.

This method of treating malignant growths is particularly applicable to the tongue, lips, and fauces, as well as to the larynx. In the latter event it is necessary to perform a tracheotomy and close the larynx so that there can be no escape of tissue to the lungs. It is remarkable how few cases of epithelioma of the lip or tongue are followed by recurrence. If treated early, when the growth involves a small area, and even where considerable tissues have been involved, the prognosis is good if properly done. There have been numerous successes in the treatment of malignant conditions of the tongue and fauces, and uniformly of the lips by this method. It is the method of choice in all conditions involving the mouth and fauces, and now a greater percentage remain cured by this method than by the knife, radium or X ray.

Tonsils.—The treatment of tonsils by desiccation includes local treatment, both for the purpose of closing the crypts and for removing portions of the tonsils. At the present time the X ray treatment seems to have supplanted the desiccation method of treating tonsils, though the latter is still largely employed by operators who have acquired a skillful technic together with the X ray.

Hemorrhoids.—For the treatment of hemorrhoids, the desiccation process is particularly advised. When operations have been done by the clamp and cautery method there have often been marked strictures in the rectum following the operation. When the desiccation method is employed, there is no stricture.

The desiccation operation consists of applying a clamp to the hemorrhoid and then desiccating the pile and shearing off with the scissors the part above the clamp, after which the desiccation spark is applied back and forth between the jaws of the clamp and the clamp removed.

By the desiccation method the mucous membrane is sealed off, so affecting it as to leave no structures or danger of secondary hemorrhage.

Phlebitis.—There are few conditions that give greater evidence of the failure of wet dressings and other local applications of heat, than phlebitis. Many cases of varicose veins come under observation that might have been relieved in the acute inflammatory stage. During past years many of these cases have come under the writer's observation in the acute stage that have been promptly relieved.

When seen during the acute stage, the prolonged application of radiant light and heat followed by adequate administrations of the static brush discharge will remove the infiltration from the inflamed vein and sufficiently increase the lumen to permit the blood to pass. The application of radiant

light and heat relieves the tension and the static brush discharge applied over the inflamed vein removes the infiltration thus an acute phlebitis is promptly cured in all cases in which the walls have not become adherent The writer and his associate have accomplished this in all early cases twice in cases involving the great saphenous vein

Varicose Ulcers—These ulcers arising, as they do, from ob truction in the circulation in parts remote from the obstructed vein cause the tissues to be starved or impoverished from lack of blood To heal the ulcer a return of the circulation is required This may often be accomplished by long and frequent exposures to reflected incandescent rays but in much less time and with greater certainty by the added use of the static bru h discharge, which, if thoroughly applied will not only remove the thickened margin of the ulcer but also the edema from the swollen limb, thus causing the blood to flow back to the region of the ulcer The ulcer should be kept well bandaged during the course of the treatment To prevent recurrence the limb must be supported by proper stockings or bandages

IMPAIRED METABOLISM

In conditions of impaired metabolism when the functions of the *organism are for any reason inactive or relatively so the administration* of conversive heat either by the use of radiant light and heat or diathermy is indicated We often find this condition in patients who are victims of constipation, who are toxic following severe illness or who are in feeble health from various causes

In these conditions the benefits derived from accelerating the general circulation and that of impaired organs and stimulating the deep cardiac and other vital centers are due to stimulation of metabolism Such applications should be given short of producing fatigue and with an intensity not sufficient to cause the patient any sense of depression

In patients who are *anemic* either from hemorrhage or some other form of secondary anemia, first apply radiant light and heat to the extent of inducing an active hyperemia of the skin, and then follow immediately while the blood is actively circulating at the periphery, by exposures to the ultraviolet rays The ultraviolet exposures should always be made short of blistering but sufficient to produce an active hyperemia of the skin These applications are as a rule given on alternate days and the length of exposure to the ultraviolet rays may in most cases be doubled at each sitting without danger of causing too great reactions

The following case report will illustrate the success of this method, the patient having been given no internal medicine to increase the red cells, but having been treated as above described

Mrs V—June 28, 1922, red cells per c mm, 2,240,000, whites 4,800, hemoglobin, 68 per cent

—July 6, 1922, red cells per c mm, 3,520,000, whites, 5,600, hemoglobin, 68 per cent

—Aug 4, 1922, red cells per c mm, 3,500,000, whites, 5,600, hemoglobin, 70 per cent

POSTOPERATIVE USE OF RADIANT LIGHT AND HEAT

There is probably no indication for the use of any measure of greater importance than the use of radiant light and heat after operations When the surgeons are brought to appreciate the value of this measure in operative cases before and after operations, bearing in mind that the action of radiant light is *practically germ destroying in character*, even when devoid of the ultraviolet rays, the measure will be used following operations in some cases while the parts are still uncovered Prolonged applications of light over the surface bring an increased blood supply to the tissues that have been shocked from trauma at the operation and so hasten the process of repair and relieve the patient from much of the soreness and suffering immediately following operation For convenience the patient may be removed to another room provided for the purpose where the dressings may afterwards be applied Conversive heat is invaluable, not only as a means of hastening repair, but for the comfort of the patient The only contra indication is the possibility of inducing hemorrhage in tissues not properly sealed off

Following such an application the patient will lapse into a quiet state with prompt relief from much of the pain and tenderness due to operation. Providing the light is not applied directly over the tissues, but over a thin dressing permitting a degree of light and infra red rays to penetrate, a great deal of relief can so be afforded the patient. Only those who have been subjected to painful conditions following an operation and been thus indulged can appreciate the relief experienced

THE OPPOSITE EFFECTS OF THE X RAY AND RADIANT LIGHT

The distinctly opposing effects of the X ray and radiant light cannot be too often stressed, particularly so now that there are so many new men in the X ray field employing the X ray in therapeutics

The writer discovered, more than sixteen years ago, *that it* was not expedient to employ the light and the X ray with the object of doing team work, when he found, after the use for one month of the combined method, that cases under treatment were making no progress as they pre-

viously had under X ray treatment The reflected light had been combating the effect of the X ray to a degree that nullified its action upon the diseased tissues Further experience has confirmed this discovery and demonstrated that distinctly opposite effects are produced by the two modalities—an inhibitory effect by the X ray and a stimulating effect by radiant light and heat This has been further confirmed in the management of X ray dermatitis for there is no measure so effective in preventing or relieving this condition as reflected light and heat It is very effective both in promptly restoring and in anticipating an X ray dermatitis in tissues overexposed This is one of the important uses of radiant energy and one which is the least appreciated by the radiologists who neglect the other rational methods

The ultraviolet rays have been demonstrated to be of great value as a prophylactic to X ray dermatitis because they do not penetrate the skin They may also be employed to protect the skin during courses of X ray treatment The ultraviolet rays may also be used in cases of X ray dermatitis before or following the reflected incandescent radiations and as a prophylactic before X ray exposures

Chronic X ray Dermatitis—In cases of this character occurring on physicians and radiographers hands there is nothing that will give greater relief than the judicious use of the ultraviolet rays This is a very important observation, and one that should be known because of the benefits to be derived

Osteomyelitis—During the treatment of post war cases the use of the ultraviolet ray and diathermy have been recognized to be of great value in the treatment of osteomyelitis There are numerous cases reported that have received only the ultraviolet treatment, and that have shown progress for obvious reasons As these rays do not penetrate to the deeper tissues the use with diathermy is essential The exposures to the ultraviolet rays in the treatment of these conditions should be made on alternate days and the application of the ultraviolet rays should then precede the application of diathermy because the more anemic the tissues are, the deeper the rays will penetrate

In this chapter the writer has endeavored to establish the *principles of action* of the physical measures employed, as to their physiological effects upon the living tissues the *practical technic of administering* the different methods for producing thermic effects upon the tissues, and finally their *application* to therapeutics

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CHAPTER XI

HYDROTHERAPY AND BALNEOLOGY

William J M A Maloney

HYDROTHERAPY

History.—Man from his advent has daily experienced the beneficent action of water. Instinctively he drank when thirsty, washed when unclean, and bathed when tired and heated. The knowledge that water is essential to the maintenance of life was among the first of all human acquirements. The relation of vegetation to water and the cleansing action of the rain, streams, and seas must have been recognized even by the earliest forms of human intelligence. Primitive man felt the need of water, saw its wide dominion in the world, wondered perhaps at the mysterious forces which dictate its form and motion, and in his dawning imagination endowed it with preternatural powers.

Symbolism characterizes all primitive mental expression. It was therefore natural that man should use water not merely when ministering to his bodily cleanliness but also when striving to convey ideas of moral purification. As late as the beginning of the Christian era we find this application of water even among the cultured Romans. Pontius Pilate, when he wished to disclaim guilt and responsibility for the Crucifixion, called for water and washed his hands before the comprehending eyes of the clamoring mob.

Analogous use of water entered into spiritual matters. To-day Hindus still seek grace by bathing in their sacred streams. Mohammedans perform extensive ablutions as an essential preliminary to prayer. Jews wash in prescribed fashion at fixed periods in order to conform to the law, and Christians are sprinkled with, or immersed in, water to wash them from the stain of "original sin" in the sacrament of baptism.

This symbolic use naturally led to the inclusion among religious practices of the application of water in the treatment of mere bodily ailments. So hydrotherapy developed under sacred auspices and the use of water as a healing agent acquired the dignity of a religious ceremony. Waters from sources distributed over the greater part of the Old World gained

more or less local reputations for special efficacy Sometimes a natural peculiarity lent awe to these waters and served to strengthen faith in their remedial powers The periodic filling of the well of Bethesda in Jerusalem and the annual rise of the Nile are typical examples of such peculiarities The moment of the appearance of these unique phenomena signified to the faithful that the endowed waters had then attained the climax of their curative powers

In some instances the special attributes of the waters were disclosed by revelation or by happy experience to the pious To some sources was given a specific virtue, thus, the famous well of St Triduana and the waters of Siloam were efficacious in eye diseases, lepers were made clean in the Jordan abdominal diseases were healed at the well of St Gingolph, and madness, sterility, and most other afflictions were cured by waters from appropriate sources The Jordan, the Nile, the Ganges, the well at Emmaus, and a few other holy waters possessed such wondrous powers that they acted practically as panaceas

The waters of Bethesda now rise almost unheeded, the pious blind no longer seek the once all powerful well of St Triduana, and, except among the adherents of the Greek Church, faith in the properties of the sacred waters of the Jordan is almost dead As the popularity of one source ebbed that of another rose In our own times to the well at the Grotto of Lourdes, near the Pyrenees, and that of St Winifred at Holywell, in Wales, seem to have been transferred many of the marvelous properties which centuries ago were vested in the holy places of the Orient From these wells wonderful cures are daily reported by eminent physicians whose belief in the verity of the phenomena they record is above suspicion and beyond question [1]

Although substances of greater potency, but of less traditional and spiritual force, have had their day and now are irretrievably forgotten, water has preserved throughout the ages its reputation as a remedial agent, owing largely to this fostering by religious bodies of faith in hydrotherapy

The rudely material benefits of bathing were early appreciated So widespread in ancient times was the custom of bathing that the Greeks and Lacedæmonians had not only private but public baths Alexander the Great is recorded to have marveled at the magnificence of the baths of the conquered Darius But *the* apostles of bathing were the Romans The Romans elevated bathing to a cult The splendor of their baths is a salient feature of their civilization In the Roman conquests a bath was built as soon as the barbarians gave the invaders a moment's leisure The more settled the new colony the more ornate was the bath Elaborate descriptions of these early baths and interminable dissertations upon bath

[1] The *modus operandi* of these cures may be just as satisfactorily explained in other ways and moreover the cures can be performed in many other ways —EDITOR

ing survive in the writings of many of the ancient authors, particularly Pliny, Seneca, and Juvenal The use of water alone was not fashionable even in the humblest baths Oils perfumes, spices, and other adjuvants enhanced the æsthetic pleasures of the e institutions Together with bathing the Romans associated massage and physical exercises The untrammeled license which characterized many of the public baths of the Romans brought bathing under the ban of the reforming zeal of the early Christian Fathers and perhaps conduced to the not overscrupulous cleanliness which sometimes served to eke out the penance of the pious anchorites who retired into desert places, and to the strikingly insignificant role which water plays in the ritualistic practices of the Christian church

The Roman influence upon bathing is accentuated in our period partly because the Romans were so prodigal in their bathing resources but mainly because our civilization is in direct succession to theirs But knowledge of the cardinal uses of water probably dates from the dawn of man The ancient Egyptians, Picts Celts Turks Moroccans Japs Indians, and Mexicans all used forms of vapor baths Besides baths of water—ice, vapor hot, cold, river spring well and sea water—other media such as sand mud peat, wine milk and even blood were used

The therapeutic use of water by physicians is as old as the art of medicine Hippocrates was hardly an enthusiast for baths but he advocated them under certain conditions in several of his writings Celsus praised house baths but was reticent about the use of mineral waters Aretæus of Cappadocia Athenæus and Rufus of Ephesus wrote at length upon the merits of certain thermal baths Agathinus was the apostle of cold baths Galen said little of baths Fallopius alluded to the diseases which may be benefited by the water at Lesbos Mitylene and other places Antyllus, Oribasius, Ætius, Paul of Ægina Cælius Aurelianus and countless others through the ages lauded the uses of water To enumerate the physicians who have practiced water treatment would be merely to catalog the fathers of medicine But until the scientific renaissance of the last century the properties and actions of water remained clouded in superstition and empiricism The pioneer work of Winternitz Brutenbach Baruch Thayer and others has now definitely established the physiological principles upon which the action of water depends Out of the chaos a certain amount of order and system has been evolved a rational basis for the therapeutic employment of water has been defined and the science of hydrotherapy which deals with the action of water upon the human body, has been erected

Here we shall confine our attention almost exclusively to water The physical characters of water will first be considered then the physiological principles of its various actions will be di cu ed, next the ways in which it can be used will be described and finally, its application to disease will be dealt with

Properties of Water

A brief outline of the properties of water is essential to a clear understanding of its uses Its distribution is universal It exists in and can readily be transformed into solid, liquid, or gaseous form.

Under ordinary atmospheric pressure, at the temperature of 0° C it becomes ice, between 0° and 100° C it is liquid, about 100° C it exists as steam In changing from fluid to ice a remarkable absorption of heat takes place if a kilogram of water at 0° C and a kilogram of water at 79° C be mixed the resulting mixture has a temperature of 39 5° C, but if a kilogram of ice at 0° C be added to a kilogram of water at 79° C, the ice disappears and two kilos of water with a temperature of 0° C remain This heat absorption explains the great efficacy of ice baths in bringing about a lowering of temperature in cases of fever

Similarly in passing from liquid to steam a tremendous amount of heat is rendered latent, hence allowing water to evaporate from a surface is one of the best means to produce cooling

Further water has a great capacity for absorbing heat, thirty-one times as much heat is required to raise one unit of water through one degree of temperature as is required to raise one unit of platinum one degree

Water cools relatively slowly It is therefore invaluable as a medium for abstracting heat, for storing heat, and for applying heat Its utility as a thermal agent is further enhanced by the ease with which its temperature can be measured, regulated, and controlled As a fluid it mixes with solids to form pastes, the consistency of which can be altered at will, it also permeates most textures, so that its application can be restricted or adapted at will to any surface

Water can readily be applied with varying and regulated pressure

When water holds a small amount of a salt in solution it is one of the best of the electrical conductors and can be used to insure intimate contact between the body and electrodes, or a bath may be arranged in a circuit, through which faradic or galvanic currents may be passed When currents are passed through aqueous solutions decomposition or electrolysis of the solution occurs

Thus, the constant current decomposes water into hydrogen and oxygen The elements at the moment of liberation from their compounds are said to be nascent The action of the nascent elements produced by such electrolysis is relatively powerful and is utilized in certain forms of baths

Water is thus an ideal medium for the application of cold and heat, electricity and pressure owing to the simplicity, precision, and rapidity with which these physical forces can through it be controlled Its power

in combating disease depends almost solely on its property as a medium Its physiological action, when a medium is essentially that of the physical force which it is conveying We shall, therefore, before proceeding to discuss the specific therapeutic uses of water in detail briefly consider the various actions of heat cold, pressure and electricity upon the body

The chief sphere of hydriatic medication is the skin The physiologic action of water upon the skin is very simple So far as hydrotherapy is concerned the skin may be regarded as a great sheet of imperfectly sheltered blood vessels and nerves The effect produced by water upon the skin is merely the expression of the reaction of the blood vessels and nerves to the physical forces applied by the water Congestion or ischemia of a part depends upon the state of the blood flow in the capillaries the capillary system is controlled mainly by the contractibility or tone of the arterioles, and upon the condition of the arterioles hangs the efficiency of the whole circulatory mechanism

The skin is richly supplied with nerve terminals which are elaborated sometimes into special sensory end organs Just as the network of vascular capillaries opens into larger channels and thus links the peripheral circulation directly with the heart, so the terminal cutaneous ramifications of the sympathetic and sensory nerves are gathered together into trunks and pass to the central nervous system A stimulus to the skin thus may powerfully affect the vascular and nervous arrangements of the whole body The skin is in fact an externalized regulating mechanism for the circulatory and nervous systems

Some areas of the skin have certain definite nervous relations to the viscera

An organ may be reflexly influenced through a particular area of skin, and affections of organs may reflexly influence special skin areas Our knowledge of these areas we owe to Head and Mackenzie and it enables us so to guide and restrict our operations that by the simple bloodless procedures of hydrotherapy we can influence viscera with as much certainty as if we were exposing them by a surgical operation

The skin, however besides being an organ of sensibility has also secretory excretory, and heat regulating functions These are subservient to nervous and vascular control A stimulation of a cutaneous secretory nerve induces an increased flow of sweat and a local increase in the blood supply An increase in the blood supply usually involves an increased sweat secretion The heat regulation of the body is largely attained through the skin In overproduction of heat by excessive muscular action or in exposure to excessive external heat the cutaneous capillaries dilate and sweating increases the evaporation of the sweat from the skin absorbs much of the surplus heat from the body If exposed to cold the cutaneous vessels contract and sweating diminishes the body heat is thus conserved Urea, xanthin, and other decomposition products of protein

metabolism may be demonstrated in the sweat, the sweat glands, just like *nearly all glands, have a vital selective affinity* for certain substances circulating in their blood supply

But as the secretory, heat regulating, and excretory mechanisms are *merely outward evidences of vascular and nervous activities* we shall first consider the action upon these activities of each of the physical forces utilized in hydrotherapy

Physical agents such as cold act mainly by virtue of their irritant properties Within certain limits of intensity a stimulus to the skin produces similar effects, whether it be caused by chemical or physical action Weak cutaneous irritants narrow the arterioles and raise the blood pressure, the increased peripheral resistance thus produced causes the heart to contract more rapidly On the contrary, intense cutaneous irritants fatigue and paralyze the normally existing innervation of the blood vessels and produce a relaxation and dilatation of the peripheral arterioles with diminution of pressure, at the same time the inhibitory action of the pneumogastric slows and intensifies the cardiac contraction, and, when excessive, may produce death by vagus tetanus

Cold —The application of cold is perceived with varying delicacy on different parts of the skin The local and general disturbances are dependent upon the degree and duration of the cold employed and the extent of the area to which it is applied, that is, to the intensity of the stimulus Long continued application of severe cold deleteriously affects the vitality *of the tissues to a degree depending upon the resistance of* the tissue exposed And when the cold is severe, besides the coldness, a pain element is noticeable in the sensation

The application of sudden cold produces first a sharp inspiration, next a pause and then a long expiration which is followed by frequent and shallow breathing This reaction is the basis of one of the best known and most efficient methods of resuscitation of the still born, indeed, it is alleged to be an essential stimulus to the establishment of respiration at birth In breech presentations, in which a premature onset of respiration might be attended by fatal consequences to the child, accoucheurs carefully swathe the extruded limbs in warm clothes The effect of cold is not confined to the respiratory mechanism, consciousness is stimulated by its application, as may be seen in the awakening of the dormant attention of *hysterics, and in the sobering of the drunk, by cold affusions* Cold is one of the most powerful nerve stimulants we possess

Owing to the stimulation of the cutaneous nerves the voluntary and involuntary muscles are influenced Investigations by means of Mosso's ergograph have proved conclusively that cold is able to increase enormously the resistance of muscle to fatigue, and also to restore the efficiency for work to muscle which is already fatigued A slight increase in the

Roehrig and Naumann quoted by Baruch

tonicity of voluntary muscle is produced And in involuntary muscle the stimulation is evident in "goose skin and in shivering

This increase of muscle tone and of muscular action and the vascular redistribution which they cause serve to augment animal heat and partly to compensate for that which is being lost Perceptible cold produces, partly by direct action and partly by reflex action upon the vasomotor center in the floor of the fourth ventricle a local constriction of the blood vessels The blood is, in consequence diminished in the cooled part and a concomitant hyperemia is produced in other areas

The result of the contraction of the involuntary muscle fibers in the skin and of the sensory stimulus given to the central nervous system is a sudden diminution in the caliber of the cutaneous capillaries This narrowing of the arterial and venous river bed raises the blood pressure, increases the endocardial stimulation, and causes an automatic increase in the force and speed of the ventricular contractions

The increased cardiac action propels an augmented supply of blood through the capillaries which are thus expanded to the fullness of their capacity The increased force of the heart is maintained for some considerable time

The contraction of the cutaneous vessels diminishes the skin secretion increases the blood pressure in the vessels of the deeper structures, and stimulates their vital processes One well known consequence of this elevated blood pressure is diuresis The increased blood pressure the increased force and frequency of the heart s action and the increased blood supply to the kidney all tend to enhance the diuretic action of cold

James Tyson measured the amount of urine and urea excreted daily by a patient suffering from enteric fever who was being treated by cooling (Brand) baths He found that the amount of urine secreted was vastly increased Before the Brand bathing was begun the urine, as is usual in febrile conditions was scanty and very concentrated After the bathing as much as 1 980 c c of urine was excreted daily As the toxicity and the amount of contained solids were increased not only was the mechanical transudation of fluid through the kidney augmented but the selective secretory properties of the renal epithelium were enhanced also

Experiments have proved that in addition to these changes there are also remarkable alterations in the relative proportions of the corpuscular elements of the blood

Cold baths produce a leukocytosis which persists at least for one and a half hours The increased blood pressure in the spleen and in the lymphatic glands, consequent on the general peripheral vascular contraction may wash out the white cells from these viscera into the general circulation

The reestablishment of the normal ratio among the blood-cells in the course of one or two hours from the time of the cold application shows the

alteration in the blood to be due to transitory changes in the circulatory system, *in the cardiac tone, and in the lumen of peripheral vessels.*

Some observers have found an increase also of red cells

On the other hand, brief application of cold to the general body surface results in an increased viscosity of the blood owing to the augmentation of the cellular elements

If the application of cold be local, remote effects are still produced These distant effects are of three classes First, owing to the constriction of the blood vessels locally, the blood is driven into other areas Thus Winternitz demonstrated that a cold hip bath augmented the volume of the arm This may be termed the remote general action Second, there is the symmetrical or intermediate response, that which affects one of a pair of structures affects the other such is seen when, say, the right hand is immersed in iced water, the left becomes blanched and cold So great is this action that Thomson states that a thermometer held in the left hand shows a fall of 2° to 5° F under such circumstances and he records a case where, during an operation upon a divided palmar arch, he produced vascular constriction in the injured hand by immersing the sound hand in iced water, and was thus enabled to proceed with his ligaturing unembarrassed by hemorrhage Third, there arise reflex influences upon subjacent or remote viscera In popular medicine this third category is well recognized Girls sometimes foolishly immerse their feet in cold water to arrest imminent menstrual flow on the eve of some entertainment Bleeding from the nose is treated by allowing a cold key to wander down the back More precisely we now apply our treatment to Head's areas in order to insure the localization of the reflex action to the viscus which we desire to influence

In order to obtain a cold stimulus, what degree of cold must be employed? The body temperature in the axilla is 98 4° F but the average temperature of the whole cutaneous surface when clad with customary garments is probably about 92° F (Winternitz) Hence to induce a 'cold reaction temperatures sensibly lower than 92° F must be employed

If the cold be slight, the effect does not proceed beyond the stage of arteriole constriction enhanced cardiac and respiratory action, and increased muscle tone And these consequences are in variable degree transient The vasoconstriction is followed soon by vasodilatation, but the beneficial effect upon the heart and the general musculature is more persistent While in the cold bath, when the cold is mild, or after emerging if it be less mild, the cutaneous blood vessels dilate, the skin reddens, a pleasurable sensation of warmth ensues, and a feeling of general well being prevails Such is the "reaction" to the cold bath To elicit it in the sick great care is necessary to temper the stimulus to the patient's strength The shock produced by the cold must not be too severe The severity is mitigated by careful regulation of the temperature of the

water, by stimulating the skin either with the impact of myriads of gas bubbles produced by aerating the water or with massage, and by shortening the duration of the bath

Heat—As already stated, the initial effect of all forms of physical stimuli is essentially the same hence the action of heat is not directly inverse to that of cold All stimuli produce initially vasoconstriction but whereas with cold this effect tends to be maintained with heat it is immediately superseded by vasodilatation which persists as long as the heat Owing to the vascular dilatation the skin reddens, a sensation of warmth prevails, sweating increases and the deeper structures are depleted somewhat of their blood The increase of the cutaneous blood sheet promotes radiation the evaporation of the excess of sweat renders latent a vast amount of heat, and the concomitant increased frequency of respiration abstracts much heat in the larger volume of expired air and water vapor hence, all these factors tend to cause a fall of temperature If the whole body be immersed in a bath of a temperature higher than 98 4° F the body temperature may rise somewhat

The relatively anemic condition induced in the viscera minimizes their activities and thus heat tends to act as a general sedative Also the direct action of heat upon the sensory nerves is pleasurable and soothing The sedative influence of heat is invaluable in abolishing convulsive seizures due to tonic conditions in children The warm bath is the surest safest and simplest sedative for the irritable nervous system of infancy The warm bath has now replaced the opiate strait jacket and padded room treatment of excitement in mental disorders in most modern asylums

The effects of heat and of cold on respiration appear to be somewhat similar each produces at first a sharp inspiration next a pause, and then a long expiration which is followed by frequent and shallow breathing

On the other hand hot baths diminish the power of muscular work unless at the same time mechanical stimuli such as douches and massage are employed but even with these adjuvants the increase in efficiency is always less than under the influence of cold applications

Together with the increased muscular effort with which respiration is performed increased production of carbon dioxid and increased absorption of oxygen occur also This evidence of increased tissue respiration is due to the active katabolism which the tissues are undergoing in their effort to produce by combustion sufficient heat to compensate for that abstracted by the cold water The effort is partly of reflex nervous origin (cf the shivering) and partly consequent upon the flooding of the viscera by the blood which has been expelled from the constricted cutaneous circulation Roughly speaking therefore we may regard the action of cold as tonic, of heat as sedative

In addition to its use as a medium for applying physical agents, water

is of great service as a solvent It is the most universal of all solvents, *the* vehicle for the administration of all soluble drugs

Water is given to remove in solution or in suspension noxious material, not only from the surface of the body, but also from its apertures and the cavities into which these apertures open The bladder, uterus, rectum, colon, and stomach are all subject to its cleansing action

Water is introduced within the lymph vascular circulation through the mouth and rectum subcutaneously, intraperitoneally, and intravenously, in order to dilute circulating toxins By making these toxins less concentrated, water makes them less poisonous It is similarly administered in cases of shock, particularly shock arising from hemorrhage, in order to refill the depleted vascular system and to provide endocardial stimulation to the failing heart These diluting and refilling actions are especially valuable in septic conditions, such as forms of scurvy, in which toxemia is complicated by profuse hemorrhages from mucous surfaces, and in diseases, such as cholera infantum, in which toxemia coexists with profuse watery alvine discharges

Water may be so completely contained in a membrane that no leaking or oozing occurs and salt may be dissolved in the water to the point of saturation without impairing the containing power of the membrane But, if a membrane perfectly containing an aqueous solution of salt be placed in contact with a weaker aqueous saline solution, or with water containing no salt, an interchange takes place through the membrane, so that the salt content of the water inside the membrane becomes equal to the salt content of the water outside the membrane Salt diffuses from the more to the less salty solution, and water, from the less to the more concentrated solution This diffusion is called osmosis The more concentrated fluid is said to have the higher osmotic pressure, and the diffusion ceases when the osmotic pressure on both sides of the separating membrane is equal Osmosis is one of the most important physical processes in life It is a determinant of the movements of all the body fluids and promotes the distribution and elimination of the contents of these fluids Water has a lower osmotic pressure than human serum, so, when swallowed, water passes through the membranous bowel into the lymph vascular capillaries Water containing so much saline in solution that it is of higher osmotic pressure than the serum causes diffusion of fluid from the lymph vascular capillaries into the bowel lumen Thus do saline cathartics produce copious watery stools Just as osmosis occurs between the bowel contents and the contents of the lymph vascular capillaries so does it occur between the contents of every living cell and the fluid bathing that cell

The principle of osmosis has been applied by Sir Almroth Wright, the distinguished Irish bacteriologist, to the treatment of septic gunshot wounds Antiseptics generally are protoplasmic poisons The best anti

septics are those which are highly destructive to the protoplasm of bacteria and relatively harmless to the healthy human cell.

Antiseptics, however, are almost invariably additional destructive agents menacing the life of the damaged cells in a wound. After careful observation of the unfortunate effect of antiseptics upon wounds arising in modern war, Wright discarded antiseptics in favor of the bland and uniformly beneficent saline solution. Saline solutions wash wounds free from all uncleanness, exudate, debris and surface organisms, dissolve, dilute and disperse toxins, and by osmosis mechanically relieve cells of their diffusible noxious contents. The natural resistance of the tissues is thus greatly reenforced and the optimal conditions for local repair are ensured. The brilliant results already achieved by Wright with this method of treating septic wounds make this new application of hydrotherapy one of the most important advances in surgery of our time.

Mode of Application

The means employed to apply water are innumerable. Many elaborate apparatus have been devised, but in proportion as their complexity increases, their usefulness as a rule decreases. Indeed, all the essential principles upon which hydrotherapy is based may be utilized through primitive domestic appliances. The ordinary full bath, partial baths such as hip baths, shower and douche baths, wrapping in wet sheets, and the application of compresses are the most important means by which water is applied. The temperature is either maintained as constant as is possible throughout the procedure or it is designedly varied.

The water baths may be medicated in various ways. Salt water baths (one-third of a pound of salt to each gallon of water), alkaline baths (one-fifth ounce of sodium carbonate or one-tenth ounce potassium carbonate per gallon), acid baths (one-third ounce dilute nitrohydrochloric acid per gallon), mustard, bran, aromatic baths such as lavender and pine, mercurial, ammoniated, sulphurated, and countless other varieties are employed.

The purpose of this medication is to add to the temperature effects, bland or irritating, sedative or stimulant action of the medicament.

Stimulant action is obtained not only by appropriate temperatures and medication, but also by suitable regulation of the duration of the application. At Nauheim stimulation is enhanced by the impact of hosts of bubbles of carbonic acid gas upon the skin. Massage and friction bring about a similar but more powerful action. By projecting water at high pressure against the body—douches, needle sprays—a similar result is obtained concomitant with the action of the water.

Hence, temperature, irritation or sedation, and pressure, may all be readily applied by means of baths. The practitioner, to employ the

remedial measure satisfactorily, must first clearly recognize the precise effects he wishes to attain, then consider what means are most simple, most practical, and most certain to procure these effects There is nothing absolute in the facts herein set forth for the use of baths in various conditions These facts are gleaned from standard authorities such as Winternitz, Baruch, Schott, and others They are meant merely as guides to treatment No one slavishly follows the pharmacopeial dose of drugs Each patient is a new experiment So the temperature, duration, composition, and frequency of the bath, and the use of pressure, or massage, must be as carefully considered and as judiciously altered as the dosage of drugs would be

The bath may be general, or local, either applied to the entire body surface, or only to some part The water may be brought into direct contact with the skin, or another medium, as a sheet, may be made the vehicle for its use

General Baths—*The Ablution*—An oilcloth or rubber sheet, covered with a blanket, upon which is laid a sheet, is prepared on the bed of the patient Each part of the body is consecutively exposed, a wet towel wrung out of water is laid on the uncovered area With the flat of the hand rubbing is applied through the towel and then the towel is removed and the part dried When the whole body is to be treated in this way it is best to take the parts in definite order This is the method of Winternitz

Baruch recommends for much weakened patients the following procedure On the day following a warm cleansing bath the patient is wrapped in long haired blankets, one passing around the body, under the arms, and inclosing separately the lower extremities, another enfolds the arms at the sides, and is tucked in about the neck and under the feet Heat is thus accumulated at the surface In one-half to one hour the face is washed with water at a temperature of 50° F Next each part is in turn bathed, rubbed, dried by gentle friction, and re covered

When the patient has become accustomed to this the ablution may be given with the subject standing He stands in twelve inches of water at 100° F, the attendant washing him down with his hands or with a towel, and pouring on parts of the body water at a temperature initially 80 F, but daily lessening till it reaches 60° F

Patients unaccustomed to cold water may begin by a partial ablution involving only the face, neck, and chest, and gradually including the whole body

Ablutions should always be rapidly performed They are useful not merely as stimulants of the peripheral nerves and vessels, but also by the reaction induced, as an index to the state of the patient They are much employed as a preparation for other forms of hydrotherapeutic treatment

The Half Bath—There should be in the bathtub enough water to im

merse the pelvis and it should be at a temperature of 70° F to 85° F To prevent retrostasial congestion the patient's head is wrapped in a cold moist towel The face is first bathed The attendant then with one hand throws water from a vessel over the front of the body, and with the other meanwhile, rubs the back Colder water is used until the patient feels cold, should his teeth chatter he should be immediately taken from the bath A warm dry sheet previously prepared, is then folded about the patient, and with it he is dried

Affusions—Water at a temperature of 50 F to 65° F is poured from above on the patient who sits in the empty tub or lies on a rubber cot The degree of stimulation is in proportion to the temperature of the water employed and the height from which it is allowed to descend upon the subject, that is the lower the temperature, and the greater the height the greater the stimulation This treatment should be very quickly given In acute cases the patient sits or lies in chronic cases he stands in water at a temperature of 100° F

By means of the affusion the sensory cutaneous nerves over a large area are mechanically and thermally stimulated and a reflex action on the heart, respiration and metabolic functions ensues The intermittent nature of the stimulation increases the effect produced

Affusions should be used with caution with precision as to temperature and with due regard to the patient's power of reaction

The Sheet Bath—A rubber sheet and a blanket are laid on one side of the bed, or on an adjoining bed There should also be in readiness several linen sheets, coarse or fine according to the effect desired, a tub of water, a cup, and a sponge The linen sheet is wrung out of water at 50° F to 80 F, spread quickly on the rubber sheet the patient whose head and face have been bathed in ice water and whose head has been wrapped in a cold wet towel to prevent retrostasial congestion, is laid on the sheet Systematically, small areas of the body in succession are warmed by gentle friction As soon as a part is heated a cup of cold water 50 F to 60° F, is poured on it This procedure is continued till the patient feels cold or shivers markedly Sometimes the subject is permitted to remain in the wet sheet for half an hour then often a gentle sleep follows The first effect of the cold wet sheet is to contract the peripheral vessels next dilatation of the cutaneous vessels occurs and is aided by the friction the cold water then again contracts them and so the process continues

Drip Sheet—The drip sheet is a modification of the sheet bath The room in which this measure is carried out should have a temperature of not less than 70 F The patient with a wet towel on his head, stands in twelve inches of water at 100 F A dripping sheet, wet with water at 7? F, is placed over his shoulders under the right arm across the back over the left shoulder across the front, and over the right arm. Quick

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to react should be tested and educated by other hydrotherapeutic measures before wet packs are given

In the cold wet pack there is an initial shock lasting from five to twenty minutes This is followed by a hyperemic cutaneous reaction There is an interchange between the cooled blood of the peripheral circulation and the warm blood from the viscera which continues until the sheet is thoroughly warm The excretion of the skin is increased and toxins are eliminated The wet pack also has a calming effect due to withdrawal of blood from the brain and the exclusion of external cutaneous stimuli To secure the antipyretic action the water for the initial pack should be 60° F to 70° F When the first pack is warm the patient should be put into another wet with water 2 F warmer As soon as the second pack is warm the procedure may be repeated raising again the temperature of the water employed 2 F This is done till four or five packs have been given or until the body temperature be satisfactorily reduced If the pack be given for its sedative action and sleep follow the patient should be permitted to remain in the pack till he awakes a cold ablution should then be given

Hot Blanket Pack —Three or four blankets are laid on the bed one blanket is wrung out of water as hot as can be borne by the hands, and spread on the bed The patient is folded in this and covered by the other blankets After a cold wet pack the sheet is warm but after a hot blanket pack the wet blanket is cool showing that there has been a diminution of heat production

The Wet Compress —Almost all forms of the compress consist essentially of a linen basis which is the vehicle for the application of the water and a dry flannel bandage which covers and secures it These vary only in shape and size to suit the region of the body to which they are to be applied, and in the temperature of the water used

The cold compress causes contraction of the peripheral vessels and should therefore, be renewed frequently enough to keep it a cold application When the stimulating compress is employed the water is at 60 F and the compress is permitted to remain *in situ* till it is warm or even dry When covered with waterproof material the compress becomes a surgical wet dressing, astringents or alcohol are often used for wetting It is so difficult to keep water compresses hot and so inconvenient to handle them that better heat retaining media such as the linseed compress, are much used

If the temperature of the patient be high the compress should be changed every half hour otherwise every hour night and day unless the patient is asleep Fresh water should be used and the compress boiled every day to prevent septic infection of the skin

The Abdominal Compress —The linen used for this compress should be in three layers of sufficient width to extend from the xiphoid process

strokes and occasional slaps are made by the operator up and down over the sheet Twice or thrice during the procedure a basin of water, 10° F or 15° F colder than the water in which the sheet has been dipped, is poured over the head and shoulders of the patient, in the intervals friction for five to ten minutes is applied On removing the sheet—which should be rapidly done—the skin is hyperemic The patient then steps out upon a woolen rug or blanket, is completely dried with soft linen towels, and then rubbed down with a warm sheet or towel If this bath greatly fatigues the patient, its duration should be lessened till the reaction and resistance are strengthened

The strength of stimulation in this measure may be greatly varied by varying any one or more of the factors, temperature, friction, the use of coarse or fine sheets, the use of the sheet dripping or well wrung out the frequency of the applications of cold water during the process, and the duration of the bath

If the hands and feet are cold even on arising it is well to induce heat to accumulate before the sheet bath is given, by piling on blankets, by giving a wet pack for one-half to one hour, or by a vapor bath for a few minutes

The Cold Rub the Cold Sponge—On arising, before losing the heat of bed, the patient is wrapped in a sheet well wrung out of water, temperature 60° F to 75° F, and is very actively rubbed down, with frequent slapping to produce an active hyperemia of the skin After rapid drying and the administration of a cup of hot milk the patient is sent out for a walk

The Wet Pack—A rubber sheet is covered by a large blanket, which hangs over one side of the bed and down over its foot A large coarse sheet, very well wrung out of water at 60° F to 70° F, the temperature being varied to suit the case is spread on the blanket The patient, his head in a wet turban, lies down with upstretched arms, the right side of the sheet is brought under the arms across the front of the body, and between the lower limbs The left side is brought over the arms and body and tucked in at the neck and feet The blanket is then drawn firmly about the patient and tucked in at the sides, neck, and feet "Everything depends upon complete exclusion of air from beneath the blanket cover If the patient is chilly he should be covered with blankets Partial packs, including only the body below the axillæ, may be given The pack lasts one half to one hour The effect varies with the duration, the texture of the sheet, the temperature of the water, the extent of the pack, and the frequency and number of times it is repeated To restore the tone of the cutaneous vessels which have been relaxed by the wet pack, the half bath, the sheet bath or the cold ablution should follow In the wet pack the reaction is entirely dependent upon the patient's capacity If the skin be previously warm the reaction is better The power of the patient

procedure, such as the wet pack The face and neck should first be bathed with very cold water, and the plunge bath then entered suddenly The whole body should be immersed in the water the head also being dipped several times The bather should exercise or rub himself in the water The plunge bath should last from a few seconds to two or three minutes It should be followed by vigorous rubbing As soon as dry the patient should exercise moderately or be massaged

The Warm Full Bath—Any bath with a temperature above that of the skin (92° F) Baruch designates a warm bath

The temperature of the room in which a warm bath is given should be between 70 F and 80 F Warm towels and a warm sheet and several hot water bags should be in readiness If there is no hot water on tap tubs of water at a temperature of 200 F should be prepared so that the bath temperature may be raised at any time if necessary The water in the bath should have a temperature of 9 F (Baruch) it is also used at temperatures between 98 F and 104 F The patient wets his face and neck with the water in the tub before entering it He lies down in the bath and should remain immersed to the chin The duration of the bath varies with the conditions for which it is administered Something warm should be provided for the patient to step out upon the warm sheet is rapidly folded around him and he is put into a warm bed and covered with blankets After a few minutes he is dried Profuse perspiration is to be avoided

When the bath is warm the irritability of the sensory nerve endings is decreased, the bath has therefore a sedative effect A hot bath—one above 100 —has a directly opposite action

The Continuous or Hammock Bath—The ordinary bathtub is usually too small for this purpose So that the patient may be able to repose in comfort for a prolonged period he is suspended in a hammocklike arrangement, which should clear the bottom of the tub Suitable rests should be provided for the head and nates If the size of the bathtub be adequate a hammock bath can be easily improvised at home opposite one another, along each of the two sides of a large sheet, four to six pieces of stout bandage are stitched The pieces must be long enough to allow the free ends of any pair to be tied under the bathtub, when the middle of the sheet rests upon the bottom of the tub After the patient has been placed in the bath upon the sheet the corresponding free ends of each pair are pulled until they are so tightened that the part of the body which their section of the sheet supports is made to assume the optimal position for its comfort Strips of bandage six inches wide may be used and the sheet altogether dispensed with If the bathtub rests directly on the floor stout wire should be twisted into S shaped hooks one curve of the S hooks on to the side of the bath to the other curve which should be within the bath the supporting bandage is fixed An India

to the symphysis pubis, and fall over the sides of the trunk. The water out of which this cloth is wrung should be at a temperature of 60° F to 70° F

The Neptune Girdle—The Neptune girdle is a modification of the above compress The linen is made long enough to encircle the body and form a double fold on the abdomen It is covered by a dry linen or flannel binder, and is changed twice or thrice in the twenty four hours, the part being sponged with cold water before each renewal

The Combination Compress of Winternitz—The Neptune girdle is applied as described A Leiter coil, arranged to have hot water passed through it, is laid on the epigastrium This hastens the reaction, and reflexly stimulates the nerves of the underlying organs When a compress is employed to reduce inflammation it should be frequently changed, never being permitted to become warm The object here is to keep the vessels of the inflamed part in a state of contraction The temperature should not be so low as to paralyze the cutaneous vessels, nor so high as to dilate them. To attain the desired end a temperature of 50° F to 60° F is suitable

Cold Applied to the Head—Instead of using the clumsy ice-bag which wets the pillow, a wet cloth may be laid on the head and held in position by a cap of coiled rubber tubing through which ice water flows

The Full Bath—This may be given hot or cold, with or without friction The cold full bath has become intimately associated with the name of Brand in the therapy of typhoid fever Brand s method for the cold full friction bath is described later

Another form of the cold full bath is the graduated bath of von Ziemssen The patient is placed in a tub which is partially filled with water at a temperature of 86° F to 90° F, and to which water of a temperature of 40° F is added till a temperature of about 77° F is attained. Friction is used, and the bath lasts one-half hour The patient, on emerging, is allowed to remain in warm blankets for fifteen minutes before he is dried and dressed

Winternitz recommends the employment of alternate half and whole cold baths, the former at a temperature of 60° F to 68 F, the latter at a temperature of 42° F to 50 F The patient remains in the half bath one to two minutes, then steps into the other for one-half to one minute, continuing the alternation according to the extent of the desired reaction.

As a hydriatic measure the cold full bath requires the strongest reactive response from the patient, it is therefore necessary especially as the reactive power is weakened in the sick, to bring to its aid the friction insisted upon by Brand and his followers

The Cold Plunge—This bath should not be entered if the subject feels chilly If necessary the skin should be previously warmed by some other

to this treatment The sitz bath acts on the abdominal and pelvic organs and vessels, its action depending, as in other forms of baths on the temperature of the water and on the duration of the bath Other partial baths are the occipital bath, the elbow the hand, and the foot baths.

The Elbow Bath.—The elbow is kept in a vessel of running cold water for ten to twenty minutes Hand and foot baths are given in the same way, but the water may be used cold or hot

Application of Extreme Temperatures—*Steam and Hot-air Baths*—These are commonly given in cabinets which inclose the entire body with the exception of the head The head and neck must be cooled during the bath The temperature of the bath usually 104° F though possibly higher, is attained gradually as the steam enters The duration of the bath varies with the indications rarely being more than thirty minutes Winternitz has devised a method for a steam bath at home A wooden raftlike frame lies at the bottom of the tub on which the bather is raised from the floor of the tub A continuous flow of hot water gives off steam in the tub, which is well covered to prevent its escape Higher temperatures can be borne in hot air than in steam baths and in steam than in hot water The bath causes rapid dilation of the cutaneous vessels, followed in a few minutes by sweating To increase the perspiration cold water is given to the patient to drink It is best after the bath to employ some cooling hydriatic measure

The radiant heat from electric light is utilized to confer temperatures of several hundred degrees These temperatures can be easily tolerated for some time provided the part to be heated is dry and is enveloped in wool or other absorbing material so that perspiration may not gather Suitably swathed, a limb can comfortably endure a temperature of 200° for half an hour The apparatus made by Dowsing and by Tyrnauer for administering radiant heat is very practical The ingenious Bergonié has utilized the heat developed by interposing resistance in an electric circuit in such a manner that he can project heat through the tissues so that it converges upon a desired focus in an organ or structure yet does not burn the skin This 'diathermia' has already proved of great worth The application of heat generated by electricity will be fully discussed in the section dealing with electricity

Russian Bath—The Russian bath is a form of steam bath

Irish Roman Baths—Irish Roman baths are hot air baths where the patient enters a series of rooms filled with air of increasingly higher temperature

Ice—The most common way of applying extreme cold is by means of the ordinary ice-bag the use of coiled tubing, the Leiter coil through which ice water is passed is however preferable The tubing is coiled in any form to fit the part to which it is to be applied The ice cradle is an ordinary hospital cradle placed over the chest abdomen or entire

rubber air ring makes a good head rest for the bather The temperature of the water should be 95° F to 100° F The water may be changed once in twenty four hours, or a constant inflow and outflow may be arranged Before the patient enters the bath his skin is anointed with a fat—lanolin or vaselin—as saturation may cause shriveling and peeling It is desirable to have the tub raised from the floor and covered with blankets to exclude air and prevent exposure A wooden board may be placed across the tub to support the blankets, and also to serve as a tray for the patient s meals The patient may be lifted from the tub to evacuate the bowels and bladder, or the urine and feces may be permitted to pass quickly away in the outflow A patient is kept in the continuous bath for any length of time, from a few hours to more than a year The continuous warm bath quiets the mental excitement of the mad particularly of maniacs who have cold or cyanotic extremities Its sedative effect upon convulsive movements in children is remarkable In septic wounds especially wounds of the bladder and abdomen, it cannot be too highly recommended In septic wounds of the limbs, arm, foot, or leg local baths are preferable, for in the hammock bath a B coli infection is soon added to the original sepsis I have never seen this B coli infection assume a menacing form, but it is both unpleasant and undesirable When a septic wound is complicated by fracture of the bones, continuous irrigation, or frequently renewed saline compresses are usually preferable to baths, for baths necessitate painful and much to be deprecated movement of the broken bones

Douches—In the douche a column of water descends from a height There is thus obtained the mechanical action of the pressure of the water as well as the effect of its temperature Many forms of the douche exist The vertical rain douche is a shower bath, in which the water falls from a perforated nozzle or rose The jet or fan douche is a movable arrangement to direct a column of water upon any part The ascending or perineal douche is a spray of water, directed upward, over which the patient sits on a stool with a ring shaped seat In the circular douche the water is directed horizontally inward from circular tiers of perforated metal tubing The Scotch douche, or alternating douche, applies heat and cold alternately, either live steam and cold water being alternated or warm water being used in place of the steam Carbon dioxid and hot air are also applied by means of douches As these are measures which are mostly practicable in institutions only they will not be further considered here

Hip or Sitz Bath—The tub used for this bath is familiar The temperature of this bath is varied, it may be cold, tepid, warm, or hot There should be enough water to reach to the umbilicus of the patient when he is seated in the tub The patient should be carefully covered to protect him from chilling Friction of the upper part of the body may be added

to this treatment The sitz bath acts on the abdominal and pelvic organs and vessels, its action depending as in other forms of baths on the temperature of the water and on the duration of the bath Other partial baths are the occipital bath, the elbow the hand, and the foot baths

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body The patient is stripped Ice-bags or pails of ice are hung from the pole of the cradle, and the whole covered over with a thin sheet The patient is kept in the ice cradle till his temperature is sufficiently reduced A hot water bag is kept at his feet to prevent chilling

Ice Rub—The ice rub is given by means of a flattened piece of ice in a cloth with which the parts of the body are rubbed in succession.

Ice Pack—The patient is stripped, and enveloped in a cold wet sheet. An ice-cap is laid on his head, and pieces of ice, carefully swathed, are placed at his sides He is rubbed by the nurse with pieces of ice, as in the ice rub Other methods of using extreme temperatures are the ether and ethyl chlorid sprays and the application of carbon dioxid snow

General Observations—Hydrotherapeutic applications are extremely valuable agents, but if skill, precision, and judgment be not employed in prescribing and in administering them they may cause great injury General cold applications should never be given in states of collapse or in exhaustion, if the temperature be subnormal, during a chill, or during a hemorrhage A patient must be warm before he is subjected to general cold When there is any suspicion of reactive weakness, the reactive capacity of the patient must be carefully trained by gradually lowering the temperature of the water, and by slowly increasing the duration of the bath, meanwhile, mechanical stimulation of the skin through aerating the water or through friction should be employed However, in the treatment of tuberculosis Aberg advises the giving of cold full baths without preparatory training of the patient Full baths of high temperature must be used with great caution In arteriosclerosis renal disease, and cerebral hyperemia, during such hot baths cold must be applied to the head to prevent the danger of an excessive flow of blood from the stimulated body surface to the head (Winternitz's "retrograde hypostatic congestion") My mistakes have occurred in the use of hot baths for comatose children Even when the greatest gentleness is used, moving the moribund may precipitate death and the sudden dilatation of the cutaneous capillaries which follows immersion in the warm bath may so reduce the endocardial stimulation in cases where diarrhea or hemorrhage has depleted the vascular system, as to cause the heart to stop beating The hydrotherapist has not the protecting secrecy of the operating room If the end comes while the patient is in a bath the relatives may consider the sanctity of death profaned before their eyes So it is well in cases of extreme exhaustion to use strychnin, transfusion pituitary extract or other stimulants, before invoking the restorative power of the warm bath

Local applications of heat or cold have little influence on general conditions, but we find few contra indications for them Local heat should not be applied for the aborting of a circumscribed inflammation as it raises the temperature of the diseased part, increases the congestion, and favors pus formation Local cold, however, is valuable, for it has the con

trary effect to heat As an analgesic either may serve Cold is usually better in pain from inflammation for it not only diminishes exudation and thus spares the inflamed nerves from pressure, but it has an analgesic effect on the nerves Heat is very serviceable in pain caused by nerve lesions Sometimes trial alone can decide which should be used It must be remembered that severe cold too long applied may impair the vitality of the tissues A protecting layer of gauze should intervene between ice and the skin and the application should be discontinued for at least fifteen minutes every hour

Although hydrotherapy may exert not merely a palliative but often even a curative influence, its habitual use may create a pernicious tendency to rely mainly or exclusively upon it Other forms of therapy— drug dietetic psychic physical and operative—should have unprejudiced consideration in the mind of the rational physician, so that the patient's rights may be sacrificed neither to therapeutic habit nor to therapeutic bigotry

SPECIAL HYDROTHERAPY

Diseases of the Circulatory System

The hydrotherapy of circulatory diseases is very simple Through stimulation of the cutaneous nerves by means of cold water charged with salts and gas, or turpentine or ammonia or other mild irritant vasoconstriction is produced in one set of arterioles and a vasodilatation in another Conceivably also the stimulation reflexly influences the heart muscle itself The vasomotor changes produce endocardial stimulation by raising the blood pressure But together with the rise there is dilatation of the visceral arterioles so that the blood is driven into and through the stagnant parts of the circulatory system The nutrition of organs in which stasis is a menace is thus improved The heart is made regularly mildly and effectively to act The coronary capillaries may share in the blood redistribution and the heart thus benefit directly from the bath But there is as yet no proof of any special implication of the coronary circulation Doubtless however cardiac nutrition is enhanced by the steadying and slowing influence of the discreetly increased blood pressure It is as it were a mild and beneficial exercise which the heart enjoys The lowing of the rate and the regular rising of the cardiac rhythm not only enables the heart effectively to empty its cavities, but in the prolonged diastoles an opportunity for regular and systematic flooding of the coronary capillaries occurs and the nutrition of the heart muscle improves

The application of cold to the precordium will slow the rapidity of an irritable and infected heart It is a valuable adjuvant to the treatment of endocarditis and pericarditis as it moderates the fevered activity and

saves the cardiac muscle from undue exhaustion Moreover, in valvular lesions, this tranquilizing of the heart spares the fragile, edematous, infiltrated valves from as many impacts as the beats that are avoided Precordial cold applied causes also a dilatation of the vessels in the heart muscle and in the pericardium, and thus aids in repelling the bacterial invasion by augmenting the blood supply

Heat cautiously applied to the precordium may stimulate the heart to more forcible, more regular, and more efficient contraction It also, reflexly, causes a constriction of the coronary vessels In weak, distended, dilated hearts the application of heat may act as a powerful stimulus and *soon strengthen, regularize, and increase the amplitude of the pulse, and* diminish the area of cardiac dulness

Arteriosclerosis—It is of great importance to recall the dual relation which the increased peripheral resistance maintains in this common malady It serves, not only as a cause, but also as an effect When faulty dilatation of the vessels exists there ensues an imperfect elimination of unknown products of metabolism which lead to a toxemia This increase of circulating toxins mainly by direct action on the vessel walls, but perhaps indirectly also, through the vasomotor nerves, gives rise to a spasm of the vessels which, in turn, leads to a still more scanty blood flow, as elimination is dependent upon the rate of renewal of the blood in the emunctory organs, such a decrease in the vascular supply serves to cripple depuration still more Thus a vicious circle is instituted and the toxemia increases The increased resistance to the vascular current in turn places added work upon the heart, which at first hypertrophies and later frequently dilates as myocardial changes occur As, except for temporary effect, drugs should not be given to obtain the desired vasodilatation, hydriatric measures possess a particular value in the treatment of sclerotic vessels By hydrotherapy it is possible to reduce the undue constriction *of the vessels thus to augment the blood flow and to promote elimination* The partial rub at a temperature of 68° F is best suited to be the initial measure If the patient withstands this mild procedure, after a few days more stimulating measures, such as the full cold rub, preferably at a lower temperature, should be instituted The duration of the rub is governed by the reaction The applications of cold to the precordium and head are indicated not only to meet the effect of the disease on the circulatory mechanism, but also to counteract the added strain placed thereon by diaphoretic measures The steam bath of moderate duration and temperature, not exceeding 110° F, when used in arteriosclerosis as a diaphoretic must be conjoined with cold applied *to the precordial region* and head The employment of the hot bath, 95° to 100° F, is of great service Venous sluggishness yields often to running foot baths

Endocarditis—*Acute*—In all cases of acute endocarditis the application of cold to the precordium is indicated, as by this measure cardiac

sedation is secured and the possibility of the occurrence of embolism is minimized The applications of choice are the precordial coil and the ice bag The selected one should be kept in place continuously for a period of, say, several days, unless the heart shows signs of weakness In the presence of non inflammatory myocardial changes cold precordial applications must be used with caution or not at all Partial rubs later in the course of the disease are advocated

Chronic —Local stimulation of the heart obtained by the use of the cold precordial coil is practiced It is claimed that digitalis may be supplanted by this application The use of heat to induce general invigoration and to reduce peripheral resistance is advisable but only under extreme caution, as the temporary increased activity resulting from thermic measures may be most potent in producing cardial dilatation Diaphoretic measures, as wet packs, partial rubs and the Winternitz modified steam bath applied five to ten minutes are of value in reduction of edema The last consists in exposing to steam the lower parts of the body while to the precordium is applied a cold coil to reduce the danger of dilatation Irregular or broken compensation and cardiac insufficiency require careful hydriatric management Much depends upon the changes in the heart muscle The use of the carefully graduated partial ablution (68 F) for several days and then the application of the cold precordial coil are the usual treatment If there be undue vascular constriction present in the cardiac insufficiency general measures may be applied to eliminate it Prominent among general measures may be mentioned the Nauheim or Schott treatment

Hemorrhoids —This aggravating malady often yields to brief, cold sitz baths of about 85 F temperature Hot hip baths are valuable to relieve pain and to ensure cleanliness and should be given night and morning After every evacuation of the bowels cleanliness should be attained by cold sponging

Acute Pericarditis —The ice-bag or cold Leiter coil is applied continuously to the precordium with the same precaution observed in acute endocarditis These measures exert decided analgesic and anti inflammatory effect Hyperpyrexia is treated with extremely cold half baths Diaphoretic measures, particularly the wet pack for two hours, are indicated by an obstinate effusion

Diseases of the Respiratory Tract

Asthma —A brief application of cold to the nape of the neck effects relief in bronchial asthma depending upon nasal conditions The form used may be an affusion, or a douche under ten pounds pressure

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respiratory or cardiac embarrassment appear the cold precordial coil is indicated High fever is controlled by wet packs

CONSTITUTIONAL AND METABOLIC DISEASES

Anemia—*Chlorosis*—To prevent heat abstraction while obtaining energetic stimulation of the nervous system is the hydrotherapeutic aim in treatment of chlorosis To lessen the heat loss all cold applications should follow some heat retaining measure, such as the warm bath at 100 F, with room temperature not below 70 F the dry pack or, without increasing the heat by additional measures the heat retention during the period of sleep may be utilized by applying the invigorating procedures upon arising in the morning

The choice of the innervating measures is great Ablutions of 80 F which are lowered two or three degrees daily and combined with mechanical stimulation rapidly given in the warm bath frequently give happy results The ablution may also follow the dry pack Wet packs followed by the half bath and rain baths are valuable auxiliaries when the nerve tone has been heightened Circular and spray douches of two to thirty seconds' duration with water, first of high temperature 95 F and then reduced to a temperature as low as 45 F followed by massage yield excellent results Hot air baths of 125° F to 160 F should precede the use of the douches

The following plan of treatment is valuable Electric light baths for fifteen to twenty minutes then the fan douche at 105 F with twenty pounds pressure for thirty seconds and then at 70 F for fifteen seconds and a dry rub followed by one hour of rest This treatment is repeated on alternate days

Secondary Anemia—The general treatment is that prescribed for chlorosis Among the special manifestations of the paucity of the blood cells the cephalalgia, and the coldness of the extremities—particularly the feet—may require special measures The headache responds happily to the use of a hot water coil applied to the neck and the cold rub confined to the legs Brief running foot baths are the most efficient measure to relieve the coldness of the feet Cold douches used after a preliminary hot application are indicated in anemia of the viscera They may be general, as the Scotch douche or localized as the fan douche applied to the abdomen

Diabetes Insipidus—Warm or cold half baths and full baths are recommended The half baths possess a special value for neurotic children

Diabetes Mellitus—In addition to attaining a strict cutaneous hygiene thus obviating the dangers of cutaneous complications hydrotherapy exercises some remedial power over diabetes, especially that form which

Acute Bronchitis—A wet pack for two hours, followed by mechanical stimulation, should be tried in an attempt to terminate the disease at its onset The cross pack (Priessnitz) at a temperature of 45° to 55° F, renewed every two hours, often lessens the cough and exerts an analgesic effect The Tissauer method of spraying may be employed for its expectorant influence after rapid application of a steam spray at 110° to 125° F, for fifteen seconds, over the upper part of the trunk, a cold fan douche is applied for three to five seconds, a rapid friction rub follows In sixteen cases in which this routine was employed Tissauer obtained ready expectoration The cold Leiter coil to the precordium may be needed, particularly in the aged Hot mustard foot baths are of proven value

Acute pulmonary affections frequently complicate the exanthemata, particularly measles When in their course, bronchitis or bronchopneumonia appears, cold half baths for five minutes at 78 8° to 71 6° F, with douching and subsequent gentle mechanical manipulations, are indicated. Extremely brief plunges into water at 61° to 54° F, succeeded by strong friction, may be used if the case is doing badly The mustard pack as practiced by Herzfeld is very efficient In this measure flannel applications are made of one to ten or twenty dilution of oil of mustard which has been made according to the directions of the German Pharmacopeia The diluent is equal parts of alcohol and water and the degree of dilution depends on the urgency of the case The application envelops the child from the neck to the knees and remains in place until the skin is markedly hyperemic When the desired cutaneous hyperemia is attained, usually in from fifteen to thirty minutes, the child is placed in a wet, 33 per cent alcohol pack At the expiration of one-half hour the wet pack is supplanted by a dry sheet This procedure should be repeated every twenty four hours and oftener if the case is very severe It produces its happy results very rapidly

Edema of the Lung—The mustard pack is claimed to be quite efficient in pulmonary edema The application is continued thirty minutes

Hyperemia of the Lung—The hot bath at 106° to 110 F for ten minutes, or the hot bath for five minutes followed by a warm pack, is the usual remedial measure employed The hot mustard foot bath is of value to induce sweating

Pleurisy—In acute pleurisy three symptoms are present, cough, dyspnea and pain, which are amenable to hydriatric treatment The cross binder through which passes a cold water coil is the most efficient measure The ice bag may be used Wet packs and mechanical stimulation, and half baths, 71 6° to 68° F, are valuable auxiliaries In event of an effusion steam baths or hot air baths, lasting ten to fifteen seconds, followed by invigorating measures are employed to induce diaphoresis The two-hourly changed cross binder may aid absorption of an effusion Should

follows their termination Some advocate the application of heat only to a degree necessary to obtain visible perspiration

Podagra.—When gout is found in association with obesity the hydriatric management laid down for that disorder should be installed at once In the more acute forms analgesia with minimization of the articular and periarticular effusions may be obtained by the use of brief cold applications to the affected parts These may be followed by circular cold compresses To combat the more chronic gout the following treatment may be employed A jet douche of 104 F under fourteen to eighteen pounds pressure is followed by a full bath at 100 to 104 F The patient is then placed in a dry blanket pack for ten to twenty minutes and then given a cool douche A rapidly administered alcohol rub ends the treatment The indirect douche at a temperature of 98 to 104 F applied under a force of fifteen pounds in a warm bath is also employed Wet packs applied from one to two hours, with a subsequent brief cold douche, such as the rain douche, are of value General diaphoretic measures such as the hot air bath until perspiration is visible followed by gradually lowered pressure douches are warmly endorsed The success which the spa treatment of gout has met seems to rest in part upon the severe hygiene there imposed upon the patients as the hydriatric values of the various waters seem no greater than that employed in the hospitals and sanitaria

Chronic Articular Rheumatism.—If in good condition the patient should be placed in the hot air cabinet for ten to fifteen minutes after which the jet douche should be applied at thirty pounds pressure if the tenderness is not extreme The hot air water douche at 110 to 115° F, and the cold douche at 80 F alternating with one another for fifteen and thirty second periods of application respectively until three or four minutes have elapsed, are utilized Another form of routine treatment is as follows The patient receives a brisk rubbing while in the full bath of 102 to 104 F which is continued eight to ten minutes Upon leaving the bath he is placed in a hot dry blanket pack, in which he remains eight to twelve minutes A five minute alcohol rub concludes the procedure Later a hot douche 103 to 104° F, may be given before the bath It should not be applied to the head Massage and a cool douche may be employed after the bath

Steam baths and wet packs may be of value They should be followed by low temperature applications as cold rubs or three to five-minute cold half baths The Scotch douche and circular compresses applied locally are most valuable It is possible by these various procedures to improve the circulation of the affected parts cause absorption of effusions and increase the mobility of the diseased joints. Atrophy of the surrounding muscles may be combated by massage or by the use of a very brief cold shower bath to the part in question Faradization of the joints for a

accompanies obesity Powerful stimulating measures are employed and are often preceded by the application of heat All efforts should be concentrated upon the attainment of a vigorous reaction Improved general metabolism and lessened tendency to acidosis are among the beneficial results obtained by the use of water

The hot air or electric light baths for five to ten minutes, next the circular douche, 105° F, for thirty seconds, then continued at 90° F for thirty seconds, and then the jet and fan douche to the entire body, 70° F, for twenty seconds, may be employed once every twenty four hours The temperature of the final water should be gradually reduced until 60° F is reached, and the jet douche pressure should be progressively increased until twenty or thirty pounds is attained Ten minute half baths at 85° F with vigorous mechanical stimulation while in the tub, preceded by wet packs, may be used The packs should be continued about forty five minutes, and should be, when applied, about 50° F Brief cold plunges and the dripping sheets accompanied by friction may be employed at home

Exophthalmic Goiter—Applications of cold either the Leiter coil or ice-bags, to the thyroid gland and the precordium serve to slow the heart. Occasionally an ice rub may be needed Wet packs for the period of one hour, combined with the cold Leiter coil to the spine and followed by a half bath, 70° to 75° F, will sometimes allay the tremor and palpitation

Obesity—The attempt of hydriotherapeutic measures in treatment of obesity is to increase general metabolism and thereby promote oxidation. In the presence of fatty myocardial changes the more severe applications should be made with caution, or with a cold precordial coil Diaphoresis by means of hot air baths, electric light baths, steam baths, full hot baths, and packs, of ten to forty minutes' duration, should be induced Then cold applications in the form of half or full baths, douches, and rubs at between 55° F and 70° F, should be employed Frequently an alcohol rub concludes the treatment Hinsdale finds the combination of full hot bath and pack superior to that of hot air bath and douches, and cites two hundred and sixteen cases in which this combination was used Of these cases one hundred and sixty eight gained weight Together with a strict dietary regime and hydro intervention, muscular exercises should be rigidly enforced Physiologically unfamiliar exercises are the movements of choice While each case presents peculiarities necessarily entailing modifications in the treatment the following prescription from Hinsdale may be followed as a guide A full hot bath at 104° F for twelve to eighteen minutes during the first three days A hot dry pack is then applied for the same length of time A cool spray, about 75° F, and an alcohol rub are the final applications After a short rest of twenty minutes long walking exercises are instituted, and massage for one hour

is mainly diaphoretic This is particularly true in the cases of interstitial nephritis As a rule, the diaphoresis is more rigorous than in acute nephritis Hot and cold applications are employed Of the former one may select the hot bath, the steam bath the hot air bath, or the electric-light bath Dry heat is less effective than moist If there be pronounced sclerotic changes in the arteries the baths must be given cautiously The application of the cold Leiter coil to the precordium will quiet the heart during the period of thermic excitation and guard against cardiac weakness The electric light bath, in thirty minute applications followed by a blanket pack has given excellent results in nephritis with edema

The following measures may be employed in the order given The electric light bath for ten minutes followed by a circular douche at 102° to 106° F at twelve to fifteen pounds pressure, for thirty to forty seconds, then the jet douche at the same temperature and pressure applied for thirty to forty seconds finally vigorous dry friction Baths at 95 to 100 F may be used in subacute cases All these hydrotherapeutic measures must be combined with dietetic treatment, especially restriction of fluids

If the rigid vessels can withstand the initial stimulation caused by the shock of cold applications the cold douche, the cold rub cold baths and the cold pack may be used Continuous packs at 70 F over the loins and abdomen, changed every five hours coupled with baths at the same temperature are highly recommended

The effect of hydriatric applications is to increase the percentage of urinary solids This increase may persist for several days after the application The cold measures are most effective in augmenting the volume of the urine

Uremia —Hot wet packs applied for thirty minute intervals every four hours and vapor baths given by covering hot bricks with wet cloths continued for an hour are employed Careful enteroclysis with water at a temperature of 110° to 120 F may be tried when all else fails Eclamptic manifestations sometimes yield to the wet pack at 70° F applied for one hour Alcohol sweat baths are of value The withdrawal of blood up to one liter should not be delayed If it be possible to obtain a strong reaction, cold in the form of half baths at 68° to 71 6 F or cold wet packs at 70 F are utilized

Prostate and Urethra—*Acute Gonorrhea* —Local thermic applications are recommended in gonorrhea The usual form employed is immersion in water at a temperature of 105 to 115 F for ten to fifteen minutes three or four times a day Local cold measures are also endorsed

Gonorrheal Arthritis —See Joint Affections

Prostatitis —Continuous irrigation as described under cystitis possesses special value in relieving prostatic diseases The water used in

short time, ten to fifteen minutes, enables the patient to withstand greater mechanical stimulation

Muscular Rheumatism—The most common varieties of muscular rheumatism are lumbago, pleurodynia, and torticollis For these hot dry packs, with moderate mechanical stimulation, may be employed with happy results Baruch recommends the use of the hot air cabinet for five to fifteen minutes, followed by the pressure jet douche The pressure should be thirty pounds unless much tenderness be present Should the condition tend toward chronicity, alternating temperature applications will prove of value

Diseases of Genito urinary System

Bladder—*Cystitis*—Inflammatory processes of the bladder may be treated by prolonged baths and irrigation The bath is usually given at a temperature of 100° F, and is continued for eight hours daily While the bath is given the bladder is continuously irrigated Hunner reports six cases of bladder disease as favorably influenced by this treatment Warm sitz baths, 90° to 96° F, for thirty to sixty minutes, are recommended The hammock bath at 95° to 100° F applied hours daily for a long period of time, even months, often affords relief However, the inconvenience and the trouble involved are hardly repaid by the results

Nocturnal Enuresis—Affusions at 60° F and the half bath are recommended Cold rubs and cold plunges at 60 8° to 64 4° F are of value to effect restoration of the lost sphincter tone If these measures are not fruitful, the short cold sitz bath may be tried

Kidneys—*Acute Nephritis*—Gentle diaphoretic measures are indicated in acute nephritis Moderate sweating can be secured by the use of hot baths, 100° to 108° F, lasting from fifteen to thirty minutes The effect of the baths is prolonged by the use of a dry blanket pack after the bath Moderate diaphoresis is highly desirable, as it places less strain on the heart and lessens the danger of uremia due to sudden elimination of a large portion of the liquid portion of the blood Such treatment is based upon the assumption that the skin may partly assume the renal excretory role This view is not entertained by many noted scientists, who claim the excretory function of the skin is so slight as to be practically negligible It may be that the warm baths increase the toxin destruction or its modification or its elimination by the kidney and bowel For the nephritis of febrile diseases, particularly that of scarlatina in infants and in the extremely young the warm bath, 100° to 101° F is used, for older children full tub baths at 90° to 100° F, with the child in a blanket, render best service Half baths at 73 to 77° F combined with strong dry rubs are recommended

Chronic Nephritis—The treatment of chronic nephritic conditions

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the acute form may be cold, that is, at a temperature of 50° to 53 6° F Care must be exercised to avoid increasing vesical irritation, which is often present Chordee may be greatly relieved by the hot dip bath

Salpinx uterine ovarian—*Amenorrhea* —Amenorrhea is usually accompanied by a relatively scanty blood supply to the uterus Its correction is usually achieved by hot local applications Hot sitz baths at a temperature of 110° to 114° F, lasting ten to thirty minutes, and the hot vaginal douche at 105° to 110° F, are the measures most often utilized Hot full baths may be pressed into service The benefits accruing from the employment of these procedures may be increased by general massage in all cases, and in a few specially indicated cases by the kneading of the pelvic tissues Later, measures to increase the systemic tone may be adopted

Dysmenorrhea —If spasm of the uterus is found accompanying painful menstruation, hot applications are efficacious Those of choice are the hot sitz bath before retiring hot douche and hot compresses The range of temperature should be from 108° to 115° F Nauheim baths are recommended by Baudler If the dysmenorrhea is due to faulty nervous mechanism, general measures should be instituted to reestablish the normal function

Chronic Endometritis —To increase the vascular tone and remove the excess of blood a vaginal douche at 108° to 115° F should be given both upon arising and just previous to retiring One to two and a half gallons of water should be used to which enough salt should be added to determine a physiological saline solution Excellent results are yielded by the Nauheim treatment if but little connective tissue overgrowth has occurred Short cold sitz baths at 85° F may be tried During gestation however, the hydriatric measures should be employed with extreme caution

Menorrhagia —Of the local applications designed to lessen profuse menstruation, the long-continued vaginal irrigation at a temperature of 120° F produces excellent results In addition general and local measures should be directed against the causal factor

Chronic Metritis —This is rarely found except as an accompaniment of endometritis Nauheim baths are recommended for those forms due to incomplete involution and inflammation In general, the treatment is similar to that of endometritis

Acute Salpingitis —The severe pelvic pain usually present may be modified considerably by prolonged vaginal irrigation Two to three gallons of normal salt solution at 110° to 120° F should be used three times daily Hot abdominal compresses are valuable adjuncts If severe pain yields not to these measures the ice-bag may be tried Should the condition become chronic, the Nauheim bath will exert a desirable sedative effect upon the pelvic circulation

Testicle—*Epididymitis and Orchitis*—Thick compresses wet in a saturated solution of magnesium sulphate at 60 F renewed every half to one hour, lessen the pain and promote absorption of the inflammatory exudate

DISEASES OF GASTRO INTESTINAL TRACT

Biliary hepatic—*Cholelithiasis*—The chief value of the hydriatic measures in the treatment of gall stones is the relief of the paroxysmal pain of the biliary colic Warm applications render the greatest service The hot bath pack is highly recommended This is applied as follows The patient is placed in a bathtub and covered with water at 104 F which is gradually increased to 115 F The entire bath has a duration of five to ten minutes When the bath is concluded, the patient is wrapped in a hot sheet and blankets and allowed to remain for thirty minutes to an hour Then an alcohol rub or affusions at 60 F are given Hot water may be given by mouth and gastric lavage may be employed The latter has proved effective in obstinate cases The trunk compress with the hot coil often gives relief

Hepatic Hyperemia—Daily cold sitz baths at 46 4 to 50 F continued for five to ten minutes and cold shower baths combined with cold movable fan douches to the skin over the liver often succeed in diverting the blood supply to the superficial tissues The venous stagnation so frequently found in the liver is usually a manifestation of cardiac or pulmonary trouble and is relieved by measures directed toward the improvement of the heart and lungs

Enteric Diseases—*Constipation*—Constipation arising in the absence of organic disease is related to an atonic or spastic condition of the intestinal musculature It is of highest importance to distinguish between these two forms as the hydrotherapeutic management of each is radically different

In the atonic form general measures to invigorate and tone the faulty muscle should be employed In patients of good physique cold may be applied at once as a compress or douche In the less heroic warmth to the point of perspiration is required prior to the administration of the cold applications For atony one may proceed by applying the hot air bath or electric-light bath until moderate diaphoresis is induced This is followed by the circular douche at 95° to 105° F under fifteen to twenty pounds pressure for one minute The Scotch douche with one-quarter inch nozzle and fifteen to twenty pound pressure, is applied over the colon at 60° and 112 F for fifteen-second interval A fan douche at 75 F and twenty pounds pressure for ten seconds to the back, abdomen and chest and massage to the abdomen with particular application to the colon, end the prescription An open air walk

augments the effects of the treatment Irrigations of cold water at 64 4° to 71 6° F, beginning with small amounts and later increasing to one quart are of value The cold rub, followed by a brief cold sitz bath of not over five minutes in duration, exerts a particularly happy effect upon the enteric neuromuscular mechanism

The spastic variety of costiveness requires relaxation measures Warm or hot applications are more efficacious than is cold in effecting this desired relaxation and sedation Warm or hot sitz baths at 104° to 110° F for twenty minutes, hot compresses to the abdomen, brief warm douches, and irrigation of water at 104° F are the measures of choice Carefully graduated cold enemata administered upon awakening have been advocated

Diarrhea —If purging be due to dietetic errors, the removal of the irritant material is imperative This can be accomplished by cold hip baths, 50° to 64° F, applied from one to five minutes Irrigations are also of service Should undue peristaltic activity be the cause of the diarrhea, hot sitz baths at 100° F given from thirty minutes to one hour, the hot coil placed over the stomach in conjunction with a wet compress, and half baths at 100° F are the indicated measures The symptomatic diarrhea of catarrhal inflammation of the intestine disappears when the hyperemia, hypersecretion, and hypermotility are reduced to normal This reduction may be realized by the intervention of moderately prolonged cold measures

One routine plan is a cold rub, followed, without drying the skin, by a sitz bath at 50° F, for ten to thirty minutes The abdomen receives a strong rubbing during the sitz bath When the bath is ended an abdominal binder is put in place and replaced when quite dry Another prescription begins with the hot air bath until the skin is hyperemic This is followed by a wet sheet rub and a simultaneous hip bath at 70° F, and a foot bath at 110° F, for ten minutes This may be given daily with gradual decrease in temperature of the hip bath to 50° F The hammock bath at 95° to 100° F often has a benign influence

Acute Enteritis —After the contents of the intestines have been expelled, the severe pain and the diarrhea may be lessened by hot applications Should chronicity develop, the half bath at 70° F reenforced by the repeated pail pour seems favorably to influence the course of the disease

Acute Appendicitis —The use of cold, as a cold coil, the ice-bag or an ice poultice, prior to operative interference lessens pain, emesis, and singultus Gauze should intervene between the skin and the ice to minimize the danger of gangrene

General Diffuse Peritonitis —The treatment here is identical with that of appendicitis Should proctoclysis be adopted, it should be very gentle

Gastric Diseases—*Atony of Stomach* —Brief cold applications enhanced by kneading the abdomen partially restore the lost tone and improve the sluggish circulation The cold rub followed by a short cold hip bath may be used The hot air bath or warm bath to induce visible sweating by a jet or fan douche at 60 F, applied to the abdomen for ten to thirty seconds, is productive of benefit

Acute Gastric Catarrh —Hyperemesis yields as a rule to ice water or ice The abdominal binder renewed every three or four hours may be employed If high fever arises general heat reducing measures are indicated

Chronic Gastritis —If atony and dilatation of the stomach are associated with this disease they should be combated by the appropriate measures The gastritis is treated by the half bath at 70 F concluded by the pail pour repeated several times Lavage often renders sturdy service in ridding the stomach of thick tenacious mucus General invigorating treatment should be instituted A cold rub upon arising, with subsequent vigorous mechanical stimulation and exercise, is followed by the jet and fan douche at 80 F This temperature may be gradually lowered in the later applications which should occur once every twenty four hours This treatment has proved very efficient

Gastroptosis —After a hot bath at 105 F for five minutes, late in the forenoon a spinal douche at 100 to 102 F of twenty pounds pressure is applied for ten seconds Then the patient returns to bed and the abdomen, particularly the epigastrium is well covered by a hot wet flannel compress, which is heated by an electric pad and renewed two hourly An elastic binder tightly encases all This prescription is recommended by Lockwood

Dilatation of the Stomach —This morbid state is usually found in conjunction with atony and its treatment is practically that of atony Lavage of the intestines and irrigation possess special value in this disorder

Nervous Dyspepsia —The hot air bath at 160 to 170 F for six minutes, succeeded by a five-minute friction tub bath at 98 F then by the rain douche of twenty pounds pressure at 95 F gradually lowered to 90 F and then by the spray douche at 80 F for five seconds followed by mechanical stimulation has given excellent results in the hands of Baruch The jet and fan douches may be used with the temperature daily decreased

Cold sitz baths at 50° to 60° F lasting from three to eight minutes, cold sheet rubs at 53° to 64 F upon arising and brief cold shower baths are of service The malady is very resistant to treatment.

Ulcer of the Stomach —To promote a greater blood supply to the stomach is one of the initial remedial steps in treatment of ulcer The cold sitz bath at 50° to 54° F for three to five minutes and trunk com

presses combined with a brief application of the hot coil to the abdomen serve further to increase the blood flow. In addition, the last measure increases the alkalinity of the blood (Buxbaum). Cold compresses to the stomach are of service. To control hemorrhage one may place ice water or ice in the rectum and apply the cold stomach coil. The latter serves more efficiently when combined with the cold stomach compress. A strict dietary regime must be used in conjunction with the hydriatric measures.

As gastric ulcer frequently occurs in chlorotics, prophylactic treatment should be instituted in all cases of chlorosis. Cold sitz baths at 46° to 57° F., for three to five minutes daily, abdominal packs renewed every three hours, with a fifteen-minute application of the abdominal coil at 104° F. once a day, are the measures often employed. A cold pack for twenty to thirty minutes, followed by half bath at 70° F. for two minutes, is of value. The pain is relieved by the application of the electric pad to the epigastrium.

Specific Infectious Diseases

Although control of the body temperature is the cardinal aim of hydrotherapeutic measures in the treatment of acute febrile disease, other manifestations of the toxemia—the rapid heart, the lessened blood flow, the quickened shallow respiration, and the emesis—are as cogent in their claims as the fever. The altered metabolism as indicated by the increase in the urinary ammonia, nitrogen, and the decrease in the urea nitrogen, the lessened alkalinity of the blood, and the alteration of the morphological elements of the circulatory fluids also claim attention. Hydriatric measures are able to exert a beneficial influence upon all these abnormal expressions. The applications in vogue are the partial ablution, the half bath, the full bath, the continuous bath, the hammock bath, the Brand bath, the wet pack, the cold rub, the trunk compress and cold applications over the precordium and to the head.

Diphtheria.—The wet pack changed at uniform intervals with the final application continued until visible perspiration appears, and then followed by a bath at 75° to 82° F., combined with vigorous affusions, yields happy results. Ice finely subdivided applied in bags to the throat often modifies the disease.

Influenza.—Hot baths are recommended. Sheet baths may be effectual in increasing the systemic tone.

Exanthemata.—*Measles.*—Full baths at 103° to 107° F., lasting from three to six minutes, according to the age of the child, given five or six times daily, have met with wonderful success according to their sponsor, Dr. Grosse. As the disease is developing, baths at 95° to 100° F. are frequently employed. Many merely sponge with cold water, especially if there be hyperpyrexia. Brief plunges into water at 55° to 60° F. often

influence the extreme cases Pulmonary complications are considered later

Scarlatina—The remedial value of hydrotherapy in scarlet fever is manifest in the decreased death rate the low percentage of complications, and the lessened period of infectivity of the disease The applications may be either hot or cold Warm or tepid sponging is applied twice daily in ordinary cases The warm bath at 90 to 98° F given once in twenty four hours is also effectual in cases of moderate severity In desperate cases baths at 90 F of five to ten minutes duration, repeated every four hours, are very efficient in alleviating the symptoms Hanson cites three characteristic cases in which these applications were of demonstrable value The hot bath at 98 to 104 F or hot air bath is employed to relieve anuresis Dry packs may be subsequently applied Although a temperature of 103 F is the indication for the application of cold, undue depression tachycardia and insomnia also demand it The Kerley graduated cool pack made of Turkish toweling applied to the torso and kept in place until the temperature is 102 F, is a valuable measure The initial temperature is 90 F by reductions of five degrees every five minutes 80 F is reached at which figure the temperature is kept thirty minutes At the expiration of that time if the fever is not perceptibly diminished the temperature of the pack is reduced to 70 F or 60 F Partial ablutions at 72° to 80 F of a duration dependent upon the readiness of the reactive response may be employed In the early stages affusions at 50 to 70 F following five to ten minute full bath at 105 F often relieve an embarrassed heart The pyrexia may be reduced by graduated ablutions which are instituted with a temperature of 90 F and with each administration reduced one degree until 75° F is reached The wet pack may be employed In a series of one hundred and ten cases treated by cool applications not one case of nephritis developed Angina and adenitis are treated by cold compresses

Syphilis—Some increase in elimination of toxic materials is caused by the diaphoresis induced by the steam cabinet bath Sweating may be also provoked by the dry pack These processes offer no interference to the cutaneous absorption of mercury On the contrary they seem to enhance it General stimulating measures are employed to increase the systemic vigor and offset the general effect of the circulating poison Of these the cold shower bath following a one-hour application of the wet pack is quite effective This procedure however, should not extend over five days The beneficial results obtained at such spas as Mt Clemens and Hot Springs depend more upon the strict mercurial treatment administered than upon the chemical properties of the various waters used in bathing The value of the bath lies in the extreme cleansing of the epidermis which leads naturally to a more rapid and thorough absorp-

tion of the mercury It is claimed that the waters of Aix les Bains, by the virtue of their calcium sulphid content, exert, when applied externally and internally, a partial curative effect in lues

Tetanus—The application of heat yields the better results, although cold measures have been the more employed Of the warm applications the hot wet pack of 100° to 110° F and the warm bath are most effective Combined with antitetanic serum, they help to oppose the advance of the disease

Pulmonary Tuberculosis—Prophylactic treatment of tuberculosis affords a valuable field for the practice of hydrotherapy The establishment of thorough prophylaxis is sometimes designated "hardening" It should be commenced early in those suspected of a tubercular predisposition It is instituted by gradually lowering the morning bath to 86° F The bath should seldom exceed ten minutes in duration, and when ended a cold affusion of 70° F should be given, and then brisk friction applied Older children may be immersed in water at 80° F for one to four minutes, and rubbed vigorously while in the bath Undue heat loss is avoided by making the application in the morning Exposure to sunlight and artificial or natural sea bathing often serve to increase the general resistance

When the disease has developed, cold sponging with ordinary tap water, practiced each morning, is valuable Poor circulation is a contraindication to this procedure The chest compress and the cross binder *applied for long periods of time are useful remedial adjuncts* in controlling pain, faulty respiration, expectoration, and cough They also exert a favorable influence on the course of the disease, stimulating the encapsulation of infective foci and enhancing the absorption of caseous or necrotic tissue This is probably due to increased pulmonary blood flow

The Cornet method of hydriatric routine may be employed The patient receives, at first, simple friction morning and night, until a strong reaction appears After one week of this, friction is made with a cloth wet with water at a temperature of 92° F This temperature is gradually decreased to 66° F in the course of several treatments One-half hour of rest is enforced at the end of the treatment If this treatment has been tolerated well, two-minute rubs in a sheet wet with 5 per cent salt solution, at 90° F, are inaugurated The brine is made more cold each day until 60° F is reached An open air walk for one hour follows the treatment Douches at 90° to 95° F may be used, except when copious expectoration or increased nervous excitability is present It is possible so to adapt patients to cold measures that they take douches of tap water at a temperature of 40 F during the winter, and apparently suffer no inconvenience Another method consists in beginning ablutions at moderate temperature, 95° F, and gradually reducing the

temperature daily, until 60° F is reached Then the ablution is supplanted by an effusion at 90° F which in turn passes through the descending steps until 50° F is obtained The affusion is practiced daily Four basins full of water are used at each treatment

In the presence of fever all violent measures are contraindicated The cool sponge bath usually controls the fever but if it fails, ice rubs should be tried Hemorrhage is met by ice-bags or the cold Leiter coil to the thorax and the thighs

Yellow Fever—Diaphoresis by means of the blanket pack should be induced In the beginning of the disease hot foot baths at 105 to 110° F may be tried

Asiatic Cholera—A cold rub in a sheet completely or partly wrung from water at 45 to 50 F or a half bath for two to five minutes at 68 to 80 F, often prevents the appearance of diarrhea Early enteroclysis with warm water often relieves the spasm of the intestine A cold rub in a sheet at 32 F, followed by a sitz bath at 8 to 12 F for fifteen to thirty minutes may check purging and favorably influence vomiting Ice-cooled water applied as rubs and sitz baths is indicated when the disease is very severe

Cholera Infantum—Cold baths are not advisable The happiest results follow the use of baths 98 to 100 F given frequently for intervals of five to ten minutes The addition of mustard to the bath will enhance the benefits accruing therefrom Care must be taken however, to protect the eyes from the irritation of the mustard and also from the infective agent of the disease If convulsions appear or collapse or low temperature ensue, heat either by the hot bath or incubator or both combined, should be at once applied The following methods taken from Budin Maloney will prove of use to combat collapse convulsion, and low temperature

'Two methods of giving the hot bath may be followed In one, the infant having let us say a rectal temperature of 83 2 F is plunged into water at 100 4 F and left there fifteen to twenty minutes The rectal temperature is then found to rise to progressively 95°, 96 8° 98 6, and 99 5° F The infant is then taken out of the bath and placed in an incubator, and the rectal temperature taken several times to find the duration of the action of the hot water

In the other form of administration the infant is immersed suddenly in water which has a temperature one degree higher than that of the body, 95 F in this case The temperature of the water is then gently increased until it reaches 100 4° F while the temperature of the infant gradually rises to 99 5 F After twenty minutes it is placed in an incubator It is found that the temperature in the latter case remains nearer the normal and falls slower than in the former'

Dysentery.—The form of this disease caused by amebic invasion of the intestine is treated successfully by cold enteroclysis with water at 40° F or even ice-cold The fluid should be administered gently in order to obviate pain Ice suppositories may be tried in the bacillary variety The careful introduction of warm saline solution into the colon after defecation is effective in controlling pain and diarrhea

Typhoid Fever.—The best results of hydrotherapeutic management of enteric fever are obtained when the treatment is instituted at the onset of the disease As a rule, the cold applications are employed, and of these the Brand bath enjoys most favor While with some authorities it has been partly supplanted by less heroic measures, accumulated statistical evidence attests its efficiency It is given as follows A portable tub is placed by the bed and two thirds filled with water at 70° F An ounce of wine or a spoonful of alcohol is given twenty to thirty minutes before the bath, or four ounces of hot coffee may be administered just before immersion After wetting the face with ice water, the patient is placed in the tub and the entire cutaneous surface mechanically stimulated by a sponge The initial shock and the feeling of coldness usually incite desire in the patient to quit the bath, but in absence of symptoms of collapse or marked shivering, immersion should continue for fifteen minutes Twice during the bath one half gallon of water at 50° F should be poured over the shoulders and head A slow pulse of small volume does not indicate withdrawal from the bath At the expiration of fifteen minutes the patient is wrapped in a sheet and blanket, placed on the bed and, if his temperature exceeded 105 5° F, evaporation is permitted in order to increase heat loss If shivering be extreme the skin is dried and he is returned at once to bed Artificial heat is undesirable, but may be needed to insure reaction, although vigorous rubbing and curtailing the length of the next bath are superior methods of furthering the reactive powers Four to six ounces of ice water are given twenty to thirty minutes after the bath, and an abdominal compress at 60 F, renewable hourly, is applied The bath is repeated every three hours or oftener if indicated A temperature exceeding 102 5 F, a low muttering delirium, extreme muscular twitching insomnia, and other manifestations of toxemia demand immediate bathing The total number of baths is variable as many as one hundred and seventy five have been given to one patient The wonderful results of the Brand bath are shown by the 50 per cent reduction of mortality from typhoid recorded by Dr Thompson from New York hospitals In Australia, of nineteen hundred and twenty three cases so treated, only 7 per cent died (Hare)

Various modifications of the Brand bath have been offered Affusions at 70 F, gradually lowered to 60 F, are endorsed by Cabot The hammock bath at 88° F, in which the patient is kept until the temperature taken per rectum is 100° F, whereupon the bath is omitted for two

hours or until the temperature again mounts to 102.5° F. seems to be nearly as efficacious as the cold bath. The cold bath may be abbreviated from eight to five minutes and employed every three hours when a poor reaction results. As the recuperative powers increase, the duration of the bath is prolonged to fifteen minutes. The partial ablution is used also to test the reaction. The general effect of these modified baths is not equal to that of the original measure.

As mentioned above, some medical men regard the cold bath as too severe, and have devised substitute entailing less distress to the patient. The ice rub, which is the strong application of a flat piece of ice to all of the body except head and neck, exposing only the part worked upon at a time, is warmly endorsed by Hare. A fall of two degrees in temperature and a slowing of the heart usually result from ice rubs; sponging with cold water is claimed to be effective in cases in which the temperature is not over 101° to 102° F. The graduated bath beginning at 95° F. and closing at 80° F. is employed. Full warm baths at 88° F. shortened the course of the disease and reduced the mortality from 10 to 8.5 per cent, according to Riess, who has employed this measure in eight hundred and nine cases. A temperature of 102° F. requires the tub for five to ten hours until the rectal temperature is 100° F. It seems, however, the substitutes fail to equal in efficacy the Brand bath. The statistics concerning these modifications are incomplete, but yet they indicate a higher death rate than follows the use of the Brand method.

Hemorrhage is met by rest and cold abdominal applications. Ice may be used with due precautions against gangrene.

Malaria.—All applications should anticipate the paroxysm, for once the chill begins it cannot be checked. Abortive treatment is efficient. A cold douche at 60° F. under twenty to thirty pounds pressure to the back for five minutes with a simultaneous hot foot bath has proved a valuable routine prescription. Cold hip baths and cold douches have cured malaria of several years standing after arsenic and quinin had failed. Two hundred and seventy-two reported cases have yielded to hydrotherapy alone. The following prescription is effective: A hot air bath is given for five to ten minutes about one hour before the chill. Then a douche or affusion at 60° F. is applied over the spine, spleen and liver from thirty seconds to a minute. The douche should be used at a pressure of from twenty to thirty pounds. While the douche is applied a hot foot bath at 100° F. should be given. These may be prescribed again in one-half an hour and two applications preceding the chill are usually able to prevent its appearance. Should a seizure appear a wet pack at 65° F. is useful in reducing the temperature and promoting elimination.

Cerebrospinal Meningitis.—Cold applications such as the ice-bag or Leiter coil to the head and back of the neck are indicated. Hot baths at

Dysentery—The form of this disease caused by amebic invasion of the intestine is treated successfully by cold enteroclysis with water at 40° F or even ice-cold The fluid should be administered gently in order to obviate pain Ice suppositories may be tried in the bacillary variety *The careful introduction of warm saline solution into the colon* after defecation is effective in controlling pain and diarrhea

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Cerebral Hemorrhage—The application of an ice-bag or cap or the cold Leiter coil to the head combined with the compresses to the trunk, are the customary hydrotherapeutic measures in treatment of hemorrhage of the brain

Cerebral Hyperemia—As this condition usually manifests itself by marked sleeplessness, measures which afford relief for insomnia may be effective in lessening the cerebral blood supply Douche applications to the spine, coupled with strong friction and cold measures to the head and the wet pack applied from thirty minutes to one hour are the means usually selected to secure the desired effect

Chorea—In event of heart complications the precordial coil should be applied Full baths at a temperature from 90° to 98° F, and not allowed to fall below 80 F during the bath of one hour's duration should be given once daily At the conclusion of the bath the extremities are gently kneaded Wet packs applied from one to one and one half hours in conjunction with the precordial coil exert a decided calmative effect The coil should be applied intermittently at thirty minute intervals A half bath at 86° F for five to ten minutes should follow the application of the wet packs A few treatments have effected complete cure in some cases

Epilepsy—Hydrotherapeutic measures exert a twofold effect in the treatment of epilepsy They hinder the progress of the disease and reenforce the action of drugs Thu with the aid of hydrotherapy convul sions may be averted or lessened in severity by smaller doses of bromids and the unpleasant condition known as bromism may be avoided Half baths at a temperature from 80 to 86 F lasting from eight to fifteen minutes and sitz baths at 85 F show valuable effects The baths may be followed by affusions and intense rubbing In the young and robust baths at 75° F gradually lowered to 68° F and of a few minutes duration are highly recommended by Binswanger Hydriatic measures are ineffectual to check a seizure once it is firmly established

Headache—Headache is often caused or accompanied by cortical hyperemia so the diversion of the blood flow from the brain and the cord to the superficial vessels is indicated This may be accomplished by the hot foot bath in water at 95 to 100 F lasting ten minutes A cold foot bath 45° to 50 F, of two minutes duration followed by strong friction is equally as potent Cold compresses changed hourly should be applied to the head The cephalalgia so frequently a symptom of brain neoplasm may often be lessened by hot mustard foot baths and hot compresses applied to the spine.

Hemicrania—This obstinate malady sometimes yields to wet packs applied from one to one and one-half hours and followed by cold rubs The drip sheet is recommended Mechanical manipulation and friction, pre-

104° F for twenty to forty minutes, repeated four times daily, lessen the pain, spasm, and tenderness and may modify the disease Early commencement of the treatment is of prime importance In one series of fifty-one cases treated by hot baths the death rate was 33 per cent. The hammock bath at 93° to 100° F may be tried The following routine is the method of applying the hot bath The patient enters a cushioned bath at 90° to 93° F, which is then slowly raised to 104° F After twenty to forty minutes have elapsed he is lifted out by means of a sheet, if much pain be present, and then covered by a blanket This procedure is also applicable to the meningismus of children If tenderness be extreme the patient should always be moved bodily on a sheet As a result of the bath the tenderness diminishes, the temperature falls, the restlessness and spasm decrease, and the patient sleeps

Pneumonia—Cold applications are selected to treat pneumonia These may be the ice bag, the cold Leiter coil, the Brand bath, half bath The ice-bag and coil are placed on the chest and on the head The reduction of the toxemia with strengthening of the heart's action and of the vessel tone is the desired aim of the treatment The beneficial results of cold hydriatric treatment are illustrated by a death rate of about 3 per cent in the report of five hundred cases managed by cold application Chest compresses and cross binders are valued measures Alcohol given before and after a bath often averts cardiac weakness The treatment for adults is the Brand bath, the details of which were discussed under typhoid fever The chest compresses wet with ice water and renewed when dry or warm, or even every ten to twenty minutes, are valuable measures The half bath at 65° to 72° F, of five minutes' duration, coupled with vigorous rubbing and affusions at 50 F, is also effective The ice-bag should be applied over gauze to the thorax and base of head An abundance of plain water should be administered, by mouth, if possible A hot mustard foot bath under blankets, to which hot water is continuously added, maintained for forty minutes, is valuable for the diaphoresis it induces In the aged, adipose, and intemperate the heart must be given careful attention

In children the cool wet pack and sponging give excellent results Compresses from 75° to 80° F, enveloping the child from the base of the neck to the navel, are also used

Diseases of the Nervous System

Cerebral Anemia—This may be either a symptom of organic change in the brain or a manifestation of morbid processes elsewhere In either case the underlying disorder should be determined and should be met with the appropriate treatment The anemia may be combated by profuse sprinkling of the face and chest with cold water at 75° F

the least possible disturbance. There is no means of sheltering the child more efficacious than the *continuous* warm bath properly given. The bath should be a hammock bath and all necessary adjustments for the comfortable suspension of the patient in it should be made before he is moved. With all gentleness, and with as little noise and disturbance as possible the patient should be lifted up by means of his bed sheet without touching him, should be carefully lowered into his bath and the bed sheet should be left under him. None other than those needed should be present. The bath should contain just enough water to cover him to the neck.

The toxic action and the pressure of the serous and of the cellular exudate first irritate the invaded nerve tissues. Most of the acute symptoms result from the irritation of the motor nerve cells in the anterior horn of the spinal cord. If the irritation continues the nerve cells die and permanent atrophy of the muscle occurs, but the first effect is to increase the tonicity of the muscles innervated from the implicated nerve cells so that involuntary and painful twitching and spasms occur with exceeding tenderness. The muscular spasm is not only maintained and aggravated, it may even be caused by external stimuli. The hot bath reduces muscular spasm and provides an unchanging sheltered sedative environment in which external stimuli are minimized. Once in the hot bath the patient need not be moved, and his exquisitely sensitive nerves are spared the heaviness of bed clothes, and much of the weight of his body. His terror of approach, his agony on movement quickly diminish, and as his muscles relax the troublesome retention of urine spontaneously disappears. So far as sleep, peace and relief from pain can strengthen his vitality, the warm bath aids him and this aid may suffice to determine a non fatal issue.

Insomnia.—Sleeplessness is frequently associated with cerebral hyperemia, but even if it depends upon other factors the wet pack for one to one and one-half hours is an admirable measure. Nightly sitz baths at 80° F., lowered two degrees every day until 60° F. is reached, applied for three minutes, are of value. The warm bath at 90° to 98° F. applied for thirty minutes before retiring may produce sleep if the patient, after being rapidly dried, be hurried into a warm bed. The room must be warm and there must be no delay between emergence from the bath and entrance into bed. When insomnia is due to a relative ischemia of the feet the best treatment is a running cold foot bath for a few minutes, followed by drying with a rough towel (Broadbent). A cold wet towel applied around the neck while a patient is in bed may yield sleep. Sea bathing often has a soporific effect.

Acute Myelitis.—The application of the cold coil to the spine for a long period of time gives the best results. The temperature should be kept at 54° F. When the acute process has dwindled, half baths and the

ceded by diaphoresis induced by the hot air bath or any general measure, may be useful

Hysteria.—The treatment is mainly symptomatic. Pain and increased sensitivity yield to long continued cold applications. The cold compress of 65° F. may be used. The *cold jet douche with an initial temperature* of 80° F., gradually decreased to 40° F., applied for one minute, is very effective in diminishing sensory excitability. Anesthesia usually yields to the same applications. An ice rub is often an excellent remedy.

The cold Leiter coil to the spine most admirably controls extravagant motor activities, such as cough, respiratory spasm, and hiccough. A cold water spray of 50° F. or a brief cold douche at the same temperature allays the respiratory excitement, while the troublesome hiccough is arrested by the application of an abdominal binder in conjunction with a hot abdominal coil. Contractures, if recent, often are alleviated and removed by the use of the hot coil or full hot baths at 104° to 110° F.; if long established, wet packs continued for one to two hours may be tried. Muscular atrophy is best combated by mechanical kneading. If paralyses exist, brief cold measures are indicated to improve the errant innervation. The cold rub at 60° F., the cold half bath at 65° F., and cold brief shower baths should be employed.

The following prescription is useful in the treatment of hysteria, particularly when associated with marked despondency. The hot air bath is applied for five minutes, then the circular douche, under twenty-five pounds pressure, at 95° F., and reduced gradually to 60° F., is administered for thirty seconds. The spray douche at 65° F. is then given for five seconds, and finally the jet douche at 50° F. is applied for three seconds over the back. This treatment may need to be prolonged for months.

Infantile Paralysis.—There exists at present neither a method to cure nor a means to arrest this dread scourge. Treatment, however, may mitigate the symptoms and by thus easing the patient may conserve his strength and enhance his resistance. Lumbar puncture relieves the pressure on the inflamed edematous nerve cells and may withdraw some of the noxious agent; the toxins circulating in the blood and lymph may be diluted by saline infusions or by blood transfusions; both of these measures will be reenforced by warm baths.

Repeated warm baths were formerly used to induce, through sweating, the elimination of the toxins of infantile paralysis. The periodic immersion and removal of the excessively tender victim entailed much suffering. Oppenheim and Wickman advised against this means of inducing diaphoresis and recommended the employment of packs instead. But even the manipulations necessary to apply packs are often intolerable. Meddlesome therapy in poliomyelitis may be disastrous. The patient *must not be handled*. The most enlightened care is that which ensures to the child

sioned by trauma an ice pack or a poultice should be employed locally. Magnesium sulphate compresses at 50° F may be used for the neuritis due to alcoholism. Wet packs applied one hour daily hasten recovery after tenderness subsides. An affusion at 50° to 60° F should follow the pack.

Occupation Neuroses.—Shower baths at 45° to 60° F, combined with a fan douche at the same temperature applied locally yield excellent results. The cold coil, ice-poultice and the ice-bag as continuous measures are valuable auxiliaries. The ice-bag and ice-poultice should be withdrawn fifteen minutes in each hour. Low temperature applications are aided by strong mechanical stimulation. Passive motion is highly effective.

Paralysis.—Toxemias and intoxications are responsible for many of the limited palsies; in these cases the general emunctories should be stimulated. Circulation to the paralyzed parts should be increased. The steam bath or the hot air bath for eight to fifteen minutes, succeeded by a cold ablution at 45° to 55° F or a cold rub produces excellent results. The Scotch douche and the wet pack at 65° F for two hours are useful measures. The palsies which follow diphtheria are benefited by the daily use of half baths at 70° to 75° F for two to five minutes. Vigorous affusions should accompany these baths.

Tabes Dorsalis.—Happy results are often produced by alternating temperature applications followed by gentle rubbing. The thermic range of these applications should be very slight. Baths at 95° to 100° F for thirty minutes to one hour may be employed. For the arterial spasms, irrespective of the site, alternating temperature sitz baths and the cold coil placed to the spine may be tried. As a rule however the crises are little affected by treatment. The following prescription from Hinsdale is effective in the beginning of the disease. The hot air baths for eight to ten minutes, the circular douche under twenty pounds pressure for two minutes at 90° to 105° F followed by the jet douche at fifteen pounds at 85° to 100° F for one minute. Then for one half minute at 85° to 105° F under fifteen pounds pressure the Scotch douche is applied and the fan douche at 80° to 85° F under fifteen to twenty pounds pressure for twenty seconds followed by an alcohol rub concludes the treatment. Daily the temperature should be decreased and the pressure increased until the fan douche reaches 60° F and Scotch and jet douches are driven by a force of twenty pounds. Half baths at 80° to 85° F applied from five to ten minutes may be used in the late ataxic stage. If the ataxia is marked or paralysis is present circular douches at 100° to 105° F under twenty pounds pressure applied for one minute following the application of the hot air bath for ten minutes, are of value. The fan douche at 105° F to 120° F will increase the effect of the above. Moderate sea bathing may be of value but this should be

hammock or continuous bath may be employed. Heat should never be used in the early stages of the disease

Chronic Myelitis.—The hammock bath at 95° to 100° F, and the continuous bath under the same thermic conditions, may exert a beneficial effect. The half bath at a temperature of 82° to 86° F given from four to eight minutes with moderate friction and gently applied affusions should be tried

Neuralgia.—Warm baths are of benefit to the neuralgias of the head The hot fomentation may be tried In sciatica the Scotch douche achieves wonderful results The steam cabinet or the hot bath pack followed by the cool half bath may be substituted for the Scotch douche The latter exerts its greatest effects in recently developed cases Indeed, one treatment may cure The effect of the jet and the Scotch douche, following a warm application is decidedly happy A hot air bath at 150° F for eight minutes, followed by a jet douche applied to the spine and the affected part for thirty to sixty seconds, beginning at 90° F and decreasing to 60° F, may be employed Then under twenty pound pressure the Scotch douche at 60° and 105° F is directed against the vertebral column Ice bags to the sciatic nerve have been endorsed The antineuralgic value of hydriatric measures is demonstrated by the record of Winternitz's clinic. He treated five hundred and eighty five cases of all types of neuralgias, and all but twenty nine were cured or improved

Neurasthenia.—A 'neurovascular training' as devised by Baruch is an absolute necessity to the majority of neurasthenics Great care must be practiced both in the reduction of temperature and in the change of measures To commence, an ablution of 85° F may be given every morning and daily the temperature be lowered until an ablution of the trunk with very cold water is succeeded promptly by a good reaction Then the ablutions are supplanted by affusions, which are graduated in the same fashion. Later the drip sheets supersede the affusion The fan douche at 80° F is then applied for one minute to the trunk and the extremities and is followed by the jet douche at 70° F on the back for thirty seconds The temperature of both douches is decreased one to two degrees daily until the lowest tolerable degree of cold is reached while the pressure is slowly increased to twenty pounds Half baths at 78° to 86° F, coupled with affusion and rubbing until a good reaction results, are of value Later, cold applications may follow To avoid heat loss the treatment should be given upon arising or after the hot wet pack or hot air bath The salt rub with subsequent fan douche at 97° to 99° F applied from four to eight minutes along the spine, thorax, and extremities possesses great value

Neuritis.—The hot applications usually afford great relief The hot bath pack, hot compresses, and hot baths of 101° F may be used The steam douche will be found of value Should the neuritis be occa

Hot dry packs for one hour should follow these measures. Local applications of hot compresses will often ameliorate the pain in very severe cases during which there should be no massage of the affected parts. In chronic gonorrheal arthritis douches are extremely potent measures. They are best applied after a hot air cabinet bath of from five to fifteen minutes duration. The jet douche at twenty pounds pressure is usually employed as a test measure and if it is well tolerated it is continued with gradually increased pressure up to thirty pounds. In the more chronic cases full pressure cold douche and moderate manipulations are the measures of choice. A careful watch must be kept for the usual cardiac accompaniments of an acute arthritis.

Acute Articular Rheumatism.—In those who possess the so-called rheumatic tendencies prophylactic hydrotherapeutic measures may avert the development of the disease. Moderately cold salt water baths at 85 to 90° F, with subsequent marked rubbing for ten to fifteen minutes often rectify the rheumatic predisposition. In the treatment of the actual disease if the pulse exceeds 90 and great tenderness be present, baths in the tub are contra indicated. With a pulse at 80 tub baths of an initial temperature of 98° F may be used. If endocarditis or pericarditis be present, the bath temperature should not exceed 98° F at any time. The cold precordial coil applied thirty minutes to one hour, two or three times a day strengthens the heart and may prevent the occurrence of cardiac complications. The temperature may be reduced and elimination increased by the repeated use of the wet pack. Two or three are given, and the last is maintained in place until diaphoresis occurs. Then a bath at 95° to 100° F of five minutes duration is given. In absence of much pain the pyrexia may be lowered further by a cold rub after the concluding wet pack is removed. An increase in fever and pain warrants a repetition of the complete procedure. Milder cases may be treated by sponge baths at 104° to 110° F three minutes with succeeding friction in cold water at 60° and 70° F. If hyperpyrexia (105° to 106° F) be present, the following routine will yield excellent results. The patient is placed in a bath at a temperature of 85° to 95° F which is then slowly reduced to 70° F. The duration of the bath is from fifteen to thirty minutes being concluded when the fever drops to 101° F. If the temperature descends even to 98.5° F after withdrawal from the bath in the absence of other signs no alarm need be felt.

Local magnesium sulphate compresses at 140° to 160° F if changed constantly may exert a marked amelioration after the procedure has been in force twenty minutes. Water at 70° F is applied with rubbing after which rest in bed is required for at least an hour. Even during convalescence a cold rub should be given upon awakening in order to lessen the danger of relapse.

employed very cautiously The hammock bath at 100° to 105° F is of benefit

Spasmodic Tic—Cold shower baths at 40° to 55° F for one to two minutes produce the best results in this disorder In general, stimulating measures are applied, but the treatment is unsatisfactory

Mania—In cases of cerebral excitement which accompanies alcoholism, dementia præcox, chorea, epilepsy, paresis, puerperal states, and general acute manias the hammock bath produces excellent results The temperature of the bath should be between 95° to 100° F and should never fall below 95° F Covering the top of the bathtub with a blanket or other covering prevents heat radiation and tends to keep the temperature of the water constant When the bath is continued for several hours reduction of the excitement is produced The duration of the bath, if the patient gives no contra indications, is proportionate to the amount of excitement present When the bath is ended the patient should be quickly covered by a warm blanket and rapidly placed in a warmed bed Daily douches graduated from 100° to 75° F decrease the cerebral exaltation The continuous bath applied daily from ten to twelve hours at a temperature from 95° to 105° F gives even superior results to those obtained by the use of the hammock bath Profuse diaphoresis induced by means of hot air, electric light, or steam cabinets succeeded by a rain bath of five minutes at a temperature of 95° F, decreased to 85° F, is of value

Diseases of the Joints

Rheumatoid Arthritis—Hydrotherapeutic efforts are directed toward the mitigation of pain, the promotion of mobility, and the improvement of circulation Five minute applications of the hot air bath (165° F to 175° F) followed by rapid ablutions of water of an initial temperature of 95° F, and reduced one degree each day until 60° F is reached, often yield valuable results The circular douche at a temperature above 85° F is a useful auxiliary measure Additional means are the circular compresses and the Scotch douche

Arthritis Deformans—Hot water baths are contra indicated except in the earliest stage of the disease Hot air baths hot sand baths, and electric light baths exert most potent effect in checking its progress It is possible by these means to reduce the amount of inflammatory fluid in and around the joints, and to increase the range of movement of the articulation, if extensive hyperplasia of the joints be not present The circular jet and Scotch douche applied for a length of time, depending upon the individual case, should follow these applications of heat

Gonorrheal Arthritis—In the acute stage the moist heat of hot baths and hot douches at a temperature of 100° to 105° F is indicated.

When the temperature is high, 106° to 110° F, a cold sheet bath accompanied by strong rubbing should be continued until the temperature reaches 102° to 103° F. During the bath the patient should have cold water thrown over him and after the bath should be placed in bed with the ice-cap in position. Enemata gradually reduced from 90° to [illegible]° F should be given in amounts from four to five pints. These may be given until the axillary temperature falls to 102° F.

The O'Dwyer treatment with affusions had the best results in the New York epidemic in 1896. The mortality with this form of management was only 6 per cent, while with all other forms it ranged from 11 to 23 per cent. This treatment is as follows: After the patient has been covered by a sheet and placed on a stretcher, an attendant standing a few feet away from the patient hurls cold water from a dipper on him until the temperature taken per rectum is 10[illegible]° F. As the body cools vigorous friction is given.

The cold sponge bath is of value. The flower pot ice water spray may be used.

BALNEOLOGY

Introduction.—Balneology is concerned with the treatment of disease by mineral waters. A mineral water is water from a natural source which contains mineral substances in solution. Since no natural water is absolutely free from minerals, all waters found in nature may be classed as mineral waters. There is, therefore, no sharp distinction between balneology and hydrotherapy. Hydrotherapy deals mainly with the external application of common water, balneology with the external and internal application of waters from special sources.

The therapeutic actions inherent in special waters not by virtue of the aqueous nature alone, but by virtue of the potency of the dissolved constituents, are utilized in balneology. At some springs only drinking is employed, at others mainly bathing, but at most both bathing and drinking are practiced. Vichy waters have specific curative properties in diabetes and glycosuria, earthy waters in gravel and stone, Kreuznach is especially efficacious in uterine complaints, Aix la Chapelle, in syphilis. Chemists have elaborately analyzed these waters to detect the elusive property in which the remedial power resides. Weary columns of statistics reveal even the most minute traces of organic or inorganic solid or gaseous matter which the water contains, but cast no light upon the mode of action of the waters. Springs which contain the most diverse mineral substances in the proportions which are most dissimilar enjoy apparently an equal potency in the treatment of the same disease. Different persons with the same disease may not be curable at the same

Intoxications and Toxemias

Alcoholism—*Acute*—The relief of this condition obtained by the use of the Turkish bath is a matter of lay knowledge. A prolonged warm bath at 100° to 102° F, with subsequent inactivity, preferably in bed, may be substituted for the Turkish bath.

Chronic—Saline infusion may be given for nervous manifestations such as excitement, insomnia, and neuritis. They often yield to prolonged wet packs. Many cases respond best to hot tub baths, lasting five to twenty minutes, at 102° to 104° F, with subsequent hot packs for ten to twenty minutes. In absence of vascular disease cold sponging may be employed.

Chronic Arsenic Poisoning—Elimination of the offending agent is the hydrotherapeutic aim. Steam cabinet baths lasting ten to fifteen minutes and the hot air cabinet, for the same length of time, followed by Scotch and jet douches or a cold rain bath, are efficient in this respect. Wet packs often exert an analgesic effect upon the intense pain sometimes present in arsenical intoxication.

Chronic Mercurialism—The use of the hot tub bath at 104° F for ten to thirty minutes with the succeeding use of hot dry blanket packs for twenty minutes is advocated. An alcohol rub is usually given when the pack is discontinued.

Chronic Morphinism—The treatment of this habit is similar to that outlined for chronic alcoholism. General invigorating procedures are valuable.

Chronic Plumbism—Elimination by all channels should be increased. The means at our disposal to accomplish this is the steam cabinet for fifteen to twenty minutes or the hot air cabinet bath. Douches, as the circular or fan, should follow these diaphoretic measures. Colic may be relieved and elimination from the intestine aided, by enteroclysis. Three to five liters of warm water may be used, and, if expulsion ensues, may be repeated in one half hour. The hot abdominal coil has also proved of service in controlling colic. Paralytic conditions are treated by Scotch douches and cold fan douches.

Chronic Nicotinism—Here the treatment may be conducted as in chronic alcoholism.

Thermic Fever—Treatment should be instituted without delay. Cold measures, combined with friction, are indicated, but some relief can be accomplished by simply hurling cold water against the body. Ice-cold sprays and affusions, cold sheet rubs with vigorous friction, ice-cold enemata, and ice-rubs are the measures usually adopted. The ice-pack is pernicious. Irrespective of the form of treatment used the patient should be completely disrobed and frequently renewed ice-pads should be placed to the neck and an ice-cap adjusted to the head.

main disease, conditions which can be remedied by attention to therapeutic detail The health resort physician takes cognizance of every mental and physical aspect of his patients His psychotherapeutic skill is as a rule, far superior to that of his colleague in general practice Aided by the atmosphere which pervades such places an atmosphere similar to that which Bernheim helped to create at Nancy and supported by municipal and institutional authority the doctor of the spa is in the position of a health giver whose word is law His rule is salutary His prescriptions are edicts of health which all must obey No private physician could impose such a regime, could practice such beneficent tyranny as is welcomed at spas Spas are little more than institutions where hygiene, hydrotherapy and faith healing are practiced and often the greatest of these is faith healing

Composition of Mineral Waters—The mineral waters contain either saline or gaseous constituents or both They are used internally and externally Externally they are used as baths partly on account of the stimulating action of their contained salts and gases and partly on account of the elevated temperature which they often have

The mineral constituents of spa waters are derived from the percolation of rain water through the soil and through various strata of the earth s surface On analysis of them sodium potassium, magnesium, calcium iron, manganese lithium and arsenic are the usual bases encountered they are combined with hydrochloric sulphuric, carbonic hydrobromic and hydriodic acids Silica is often present Sometimes the metals occur as sulphids Oxygen carbon dioxid nitrogen sulphurated hydrogen, and other gases may be present in solution

The amount of gas which will dissolve in a liter of water varies with the nature of the gas Fresh water dissolves more gas than salt water but the most important factor in the solution of a gas is the pressure of the gas The most valuable of the gases in balneology is carbonic acid At 0° C and 760 mm pressure 1 liter of pure water can absorb 1 713 liters of CO_2 and the solution is saturated At greater pressure more CO_2 can be dissolved the solution can be supersaturated The dissolved gas is invisible and its solution is not sparkling Heat or agitation or reduction of pressure converts the tranquil solution of carbonic acid gas into a sparkling bubbling liquid owing to the throwing out of solution of the carbonic acid gas In comparing the CO contents of various springs it is for practical purposes only necessary to ascertain the degree of supersaturation Anthony, by experiment determined that the supersaturation was 25 per cent at Bad Nauheim 31 per cent at High Rock Baths Saratoga 33 per cent at Kayaderosseras Baths Saratoga 38 per cent at Bad Homburg 4[illegible] per cent at Bad Kissingen 50 per cent at Bruckenau and [illegible] per cent at Lincoln Bath Saratoga At the Lincoln Baths, Saratoga, the greatest supersaturation known in balneology is to

spring Artificially prepared waters of apparently identical composition are admittedly less efficacious, and even questionably useful

To what, then, does the natural source owe its value? Recently radioactivity has been demonstrated in the waters of many springs Doubtless such radio activity is powerful to benefit, but the patient must first be thoroughly educated to its significance and then be convinced of its presence To the less credulous the waters have properties more tangible and commonplace If analysis shows a special source to be well aerated and to contain sodium, calcium, or other base combined with hydrochloric, sulphuric, or other acid, the merit of the water is that inherent in water the world over, plus that due to its gaseous, metallic, or metalloid constituents The value of such constituents is their essential value It is no mysterious virtue Iron or arsenic exerts the same pharmacological effect whether it be administered as a natural solution or as a *pharmaceutical preparation* The action of alkaline or of sulphurated waters does not vary when it is sought in an Arcadian spa and when it is invoked in a crowded town The worth of balneological treatment lies not in the water and its contents. These have a certain importance, but the prime factors in the cure are the psychic influences which accompany it, the absence of work and worry, the change of climate and environment which invest it with healthy interest, the regulation of sleep and diet and exercise which reinforce it, and the medical skill which controls all

In spas, to every mental stimulus of a non religious nature which tends to health, appeal is made The physician who recommends the treatment begins the therapeutic suggestion by his declaration of faith in the spa and his panegyric on the evidences of its curative powers A belief in the efficacy of the spa is accepted by natives as part of their national inheritance, one of the virtues of their fatherland, by foreigners, as conferring upon them at once a certain desirable cosmopolitanism. The pinnacle of faith is reached by the spa doctor who sees in the waters a cure for everything, from fibroid tumors to supernumerary digits At the spa itself everybody assembles for one purpose—to strive for health The social instinct among the similarly sick, the atmosphere of salutary competition among convalescents, the regular restful hygienic mode of life pursued, and the climatic conditions enjoyed, exercise a cumulative curative action on the overstrained, the depressed, and the weary Dietetic and hygienic regulations are more or less stringently enforced The regime in itself is curative for the majority of the slightly ailing who flock to these resorts The routine flushing of the system with innocuous fluids eliminates the lingering toxins of years In nearly all spas the medical skill at the disposal of the visitors is excellent—skill in handling the particular maladies which are specially catered for at the spa and, particularly, skill in alleviating slight conditions superimposed upon the

main disea e conditions which can be remedied by attention to therapeutic detail The health re ort physician takes cognizance of every mental and physical a pect of his patients His psychotherapeutic skill is, as a rule, far superior to that of his colleague in general practice Aided by the atmo phere which pervades uch places, an atmo phere imilar to that which Bernheim helped to create at Nancy, and supported by municipal and institutional authority the doctor of the spa is in the position of a health giver who e word is law His rule is salutary His prescriptions are edicts of health which all must obey No private physician could impose such a regime could practice such beneficent tyranny, as is welcomed at spas Spas are little more than institutions where hygiene, hydrotherapy and faith healing are practiced, and often the greatest of these is faith healing

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be found The efficiency of the Nauheim Bath is largely due to the action of carbonic acid gas bubbles on the skin This action can be obtained in unequaled degree at Saratoga Springs, New York

Temperature —The temperature of the waters varies greatly Waters which issue hot, derive their heat from that which exists at great depths in the earth Indeed, it has been alleged that the hotter the spring the deeper is its source Springs that have a temperature above the average of the locality in which they occur are called *thermal* Thermal springs of a temperature between 70° F and 98° F are distinguished as *warm* and those above 98° F as *hot* The temperature of the waters at Aix la Chapelle is 167° F , at Carlsbad, 162° F , at Bath, 120° F The following list (Hinsdale) gives the location and distribution of the chief thermal springs in the United States

	Temperature Degrees F
Lebanon Spring Columbia Co New York	75
Spring near Carlisle Perry Co Pennsylvania	72
Rockbridge Baths Virginia	74
Sweet Chalybeate Alleghany Co Virginia	75
McHenry s Thermal Spring Scott Co Virginia	68
Healing Springs Bath Co Virginia	84
Warm Springs Bath Co Virginia	96 3
Hot Springs Bath Co Virginia	106
Berkeley Springs Morgan Co Virginia	74
Sweet Springs Monroe Co West Virginia	79
New River White Sulphur Giles Co West Virginia	80
Hot Springs Buncombe Co North Carolina	92–117
Citadel Green Charleston South Carolina	99 5
Warm Springs Meriwether Co Georgia	70– 90
Livingston Spring Sumter Co Alabama	68
Bailey s Springs Alabama	72– 80
Hot Springs, Arkansas	46–147
Hot Springs South Dakota	98
Liberty Hot Springs Colorado	140–150
Hot Springs Canyon City Colorado	169
Hot Sulphur Springs Middle Park Colorado	110–117
Glenwood Springs Colorado	124
Idaho Springs Colorado	106
Las Vegas Springs New Mexico	110–140
Hudson Hot Springs New Mexico	149
Ojo Caliente Taos Co New Mexico	90–122

At thermal baths local painful conditions, nerve or joint troubles of gouty or rheumatic origin, are treated

Radio activity —The radio activity of mineral waters arises from the presence of a gas known as the radium emanation This gas is derived from the radio active salts contained in the earth where the spring has its source The emanation is soluble in water but decomposes continuously at a known rate, and, like other gases is driven out of solution by boiling

Radio-activity is estimated by means of the electroscope or, with greater accuracy, of the fontactoscope of Engler and Sieveking. The result is stated in Mache units (M. U.) but confusion in standardizing the units exists so the radio-active values of various springs are not easily judged. Shearer in his report upon the radio-activity of Glen Springs states that the Nauheim Spring there contains 68 M. U. per liter and cites from *Radium* (April, 1915) the radio-activity of Hot Springs, Arkansas, as varying between 0.7 and 23.6 M. U.; of Saratoga Springs, 1.08 and 1.04 M. U.; and of Colorado Springs, 0.21 and 10.4 M. U. Semblin quoted by Hinsdale estimates that there are 274 M. U. per liter in Magnesia Spring, 214 M. U. in Boiler Spring, 157 M. U. in Hot Sulphur Spring and 105 M. U. in Swimming Pool Spring at Hot Springs, Virginia. Radio-active mineral waters are used chiefly to accelerate metabolism. Success is said closely to attend them in the treatment of the metabolic toxemias which cause gouty and rheumatoid states with accompaniments as myositis, neuritis and arteriosclerosis.

Classification

The amounts of the various constituents vary greatly in different sources. According to the essential constituents of the water, sources are classified as indifferent, alkaline, saline, chalybeate, sulphurous, etc. Many waters do not belong to any one group. Thus, saline sulphur springs are common; others could rightfully be classed in any of several categories. Hence, this mode of classification does not distinctly differentiate but merely groups somewhat similar waters conveniently together. The following are some of the most important sources.

Simple Thermal Waters.—Simple Thermal Waters include waters of high temperature and small mineral content.

America.—See list enumerated under Temperature (page 456).

Great Britain.—Bath, Buxton, Matlock.

France.—Bagnères de Bigorre, Néris, Bagnoles de l'Orne, Plombières, Dax, St. Amand.

Germany and Austria.—Badenweiler, Teplitz, Bohemia; Gastein, Salzburg, Austria; Wildbad, Württemberg; Schlangenbad (near Wiesbaden).

Italy.—Battaglia, Bormio, Pozzuoli.

Switzerland.—Loeche-les-Bains, Ragatz.

These waters are usually soft; they are not frequently used internally, but are employed almost solely as baths.

Common Salt Waters.—As common salt is of almost invariable occurrence in natural waters, this class has indefinite and arbitrary limits. In the waters which are here mentioned common salt is the essential constituent.

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Sweet Chalybeate Alleghany Co Virginia	75
McHenry's Thermal Spring Scott Co Virginia	68
Healing Springs Bath Co Virginia	84
Warm Springs Bath Co Virginia	96.5
Hot Springs Bath Co Virginia	106
Berkeley Springs Morgan Co Virginia	74
Sweet Springs Monroe Co West Virginia	79
New River White Sulphur Giles Co West Virginia	85
Hot Springs Buncombe Co North Carolina	[illegible]
Citadel Green Charleston South Carolina	39.5
Warm Springs Meriwether Co Georgia	70–90
Livingston Spring Sumter Co Alabama	68
Bailey's Springs Alabama	[illegible]
Hot Springs Arkansas	[illegible]
Hot Springs South Dakota	95
Liberty Hot Springs Colorado	140–150
Hot Springs Canyon City Colorado	[illegible]
Hot Sulphur Springs Middle Park Colorado	[illegible]
Glenwood Springs Colorado	[illegible]
Idaho Springs Colorado	[illegible]
Las Vegas Springs New Mexico	110–140
Hudson Hot Springs New Mexico	[illegible]
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Italy.—Battaglia Bormio Pozzuoli

Switzerland.—Loeche-les Bains Ragatz

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Rockbridge Baths, Virginia	74
Sweet Chalybeate, Alleghany Co., Virginia	75
McHenry's Thermal Spring, Scott Co., Virginia	68
Healing Springs, Bath Co., Virginia	84
Warm Springs, Bath Co., Virginia	96.3
Hot Springs, Bath Co., Virginia	106
Berkeley Springs, Morgan Co., Virginia	74
Sweet Springs, Monroe Co., West Virginia	[illegible]
New River White Sulphur, Giles Co., West Virginia	[illegible]
Hot Springs, Buncombe Co., North Carolina	[illegible]
Citadel Green, Charleston, South Carolina	99.5
Warm Springs, Meriwether Co., Georgia	[illegible]–90
Livingston Spring, Sumter Co., Alabama	68
Bailey's Springs, Alabama	[illegible]
Hot Springs, Arkansas	46–[illegible]
Hot Springs, South Dakota	98
Liberty Hot Springs, Colorado	140–150
Hot Springs, Canyon City, Colorado	[illegible]
Hot Sulphur Springs, Middle Park, Colorado	110–117
Glenwood Spring, Colorado	[illegible]
Idaho Springs, Colorado	[illegible]
Las Vegas Springs, New Mexico	110–140
Hudson Hot Springs, New Mexico	[illegible]
Ojo Caliente, Taos Co., New Mexico	90–[illegible]

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Radio activity.—The radio activity of mineral waters arises from the presence of a gas known as the radium emanation. This gas is derived from the radio active salts contained in the earth where the spring has its source. The emanation is soluble in water, but decomposes continuously at a known rate, and like other gases, is driven out of solution by boiling.

Germany and Austria.—Bocklet Pyrmont Waldeck, Bruckenau, Pippoldsau, Elster, Saxony Schwalbach Petersthal

Italy—Santa Catarina

Switzerland—St Moritz

Calcareous Group—These waters contain salts of alkaline earths calcium and magnesium sulphate, and carbonate

America—Cherry Valley, New York Holston Virginia, Chittenango New York, Waukesha Wisconsin Clifton Springs New York Tate Epsom Tennessee, Bedford Pennsylvania Alum Rock California Catoosa Georgia, etc.

England—Bath

France—Bagneres de Bigorre Contrexeville Vittel

Germany and Austria—Inselbad Lippspring Wildingen

Switzerland—Loeche les Bains Weissenberg

Sulphur Waters—These waters contain sulphids Many of them also contain chlorids Some of them are warm

America.—Calistoga Springs California Santa Barbara Springs, California Glenwood Springs Colorado Hot Sulphur Springs, Colorado also in Utah and Arkansas

British Isles—Ballynahinch (Co Down Ireland) Harrogate England (13 per 1 000 NaCl) Llandrindod Wells Wales Moffat Scotland, Strathpeffer Scotland

France—Aix les Bains (warm) Louchon Allevard Pierrefonds, Amelie-les Bains (hot) St Honore-les Bains Bareges St Sauveur, Canterets (warm) Uriage Eaux Bonnes (warm)

Germany and Austria—Aix la Chapelle Baden Weilbach, Nassau

Switzerland—Baden Heustrich Schinznach Gurnigel Lenk

Egypt—Helouan.

Arsenical Waters—These waters contain arsenites or arsenates

America—Crockett Arsenic Lithia Springs (Virginia) Thompson s Bromine Arsenic North Carolina Harbin Hot Sulphur Springs California

France—La Bourboule Bous ang Vals

Germany and Austria—Cudowa Roncegno Linda Pausa Levico South Tyrol

Italy—Civilina Ceresole Reale

The Action of Mineral Waters

The effect of the ingestion of the large quantities of water which forms part of the routine treatment at mineral springs is to flush out the stomach intestine kidneys and other organs The water, by its bulk, stimulates peristalsis and voids in solution or suspension, the putrescent material from the bowels *Some of the water is absorbed The bulk of*

America—Fruit Port, Michigan, Grand Haven, Michigan, Mount Clemens Mineral Springs, Spring Lake Well, Salt Spring, Virginia, Ocean Spring, Alabama

Great Britain—Droitwich (brine, 300 parts per 1,000), Worcestershire, Nantwich (brine), Woodhall Spa (chloro bromo iodid), Lincolnshire

France—Bourbonne les Bains (hot), Salies de Bearn, Chatelguyon (warm, gaseous), Salins du Jura, La Mouilliere (chloro bromo-iodid), Salins Moutiers (warm)

Germany and Austria—Baden Baden (weak, 2 parts per 1,000), Nauheim (warm, gaseous), Hesse (near Frankfort-on Main), Berchtesgaden, upper Bavaria Oeynhausen, Westphalia, Homburg (cold, contain also bicarbonate of iron) (near Frankfort-on Main), Ischl, Salzkammergut Austria, Reichenhall, Bavaria, Kissingen, Bavaria, Soden (near Frankfort-on Main), Kreuznach, Rhine Province, Wiesbaden (hot)

Switzerland—Bex, Wildegg

Alkaline Waters—Waters containing sodium bicarbonate Three subgroups (1) simple alkaline waters, (2) alkaline and common salt waters, (3) alkaline and sodium sulphate waters

America—Capon Springs, Virginia, Glenwood Springs, Colorado, Glen Summit Springs Pennsylvania, Geyser Spa, California, Gettysburg Springs Pennsylvania Manitou Soda Spring, Colorado, Minnequa Springs Pennsylvania Saratoga Springs, New York

France—Vals, 1,[*] Vichy, 1, Allier, Royat, 2

Germany and Austria—Bilin, 1, Fachingen, 1, Carlsbad, 3, Bohemia, Neuenahr, 1, Coblentz Franzensbad, 3, Bohemia, Ems, 2, Hesse-Nassau, Marienbad, 3, Bohemia

Switzerland—Tarasp, 3

Bitter Waters—These contain chiefly magnesium sulphate

Great Britain—Cheltenham (chlorids also), Leamington (chlorids also)

France—Brides

Germany and Austria—Apenta Friedrichshall, Pullna

Spain—Rubinat

Chalybeate or Iron Waters—These waters contain iron in medicinal quantities

America—Rawley Springs Rock Iron Springs, Church Hill Alum Springs, and others, Virginia, Sharon Springs, Saratoga Springs, New York, Pacific Congress Springs California

England—Tunbridge Wells

France—Forges les-Eaux, Orezza

Belgium—Spa

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[*] The figures refer to the subgroup

Iron Arsenical Sulphide and Earthy Waters—Waters containing iron and arsenic in sufficient amounts to be of therapeutic value exert merely the ordinary pharmacological action of these substances They are used mainly in anemias, neuralgias, and skin diseases The action of the sulphide waters is not evident They are said to stimulate secretion of bile and to have an expectorant action Their use in syphilis is greatly lauded, but where it is most exalted mercury is also given as a substantial prop to its curative powers Sulphids in sufficient quantity are protoplasmic poisons To class the sulphide mineral water as an alterative is to admit ignorance of the basis of its action The earthy waters those containing the sulphates and carbonates of calcium chiefly, have probably little action apart from that of the water They are given as antacids, as astringents and sedatives in acid dyspepsia and in diarrhea Their benign flushing power is used in hepatic and gouty conditions and in chronic cystitis, gravel and stone

Resultant Action of Mineral Waters—Few waters have only one content As the waters were classed according to their predominant constituent, so is their action regarded as being that mainly of this essential constituent, but the predominant constituent of any mineral water is not that which occurs in greatest quantity but that which is most active medicinally Some waters containing small quantities of arsenic exert more action by virtue of their arsenic than they do by virtue of all their other constituents We therefore have to deal with compound actions some of which are negligible and some of which are important Of the important actions some reinforce and some tend to neutralize those of the other constituents The precise effect therefore of any given mineral water is the resultant of so many actions that it is difficult to presage, and we must more or less empirically base our expectations of its value upon observations of physicians and patients

In addition to these mineral factors the presence of carbonic acid gas also modifies the action of the waters The carbonic acid is supposed to be at once stimulating and sedative It certainly renders waters more pleasing to regard and more palatable to take The physical effects of the impact of gas bubbles upon the skin are utilized in stimulating baths

Many mineral sources yield waters at high temperatures and the temperature also modifies the therapeutic action

Indications for and Choice of, a Spa

For those who have the habit of excess in work or in pleasure a periodic visit to a spa is a useful precaution For others 'taking the cure is an essential part of social routine For others again, especially the middle aged in easy circumstances who seek relief from the tedium of living by intensive devotion to minor ailments the spa is a refuge to

the circulating fluid is increased, the greater volume affords endocardial stimulation and the circulatory efficiency may be enhanced The resulting increased blood pressure promotes diuresis The vital processes are all quickened, tissue change increases, mucous membranes secrete more freely, and the skin glands function more actively To dilute toxins to dissolve them, and to promote their excretion, are the main actions of water

But a feeble atonic stomach musculature may not lightly tolerate the ingestion of large volumes of water, embarrassed hearts may perceptibly fail under the added burden which must be propelled, and overworked diseased kidneys may quickly be exhausted by the laborious functional activity thus demanded

Action of Salines—The dialytic and irritant properties of salines inhibit absorption of liquids, augment peristalsis, and increase the fluid contents of the intestines, so as to produce more or less free purgation The presence of increase of salts in the blood causes a livelier interchange between the circulating blood and the fluid in the tissue spaces diuresis ensues, a mild expectorant action is produced, and metabolism generally is increased

Salines are said to increase the solubility and diffusibility of albumins In food a considerable amount of salt is customarily ingested How far the added quantities of salines, which are absorbed during mineral water cures, exert an influence on metabolism, is doubtful The action of the salines varies somewhat according as the base and the acid radical which they contain The action of the metallic element need not further be discussed here The rate of diffusion of chlorids, sulphates, and iodids determines whether they are essentially purgative or diuretic Radicals of large molecular weight, such as sulphates, diffuse with difficulty and, therefore, tend to act mainly as cathartics Whereas, with radicals of small molecular weight, such as chlorids, an interchange takes place readily between the bowel contents and the portal circulation so that a considerable proportion of the salt may be ingested Further details as regards the mechanism of the action of salines belong more properly to the realm of pharmacology Salt and bitter springs are used in constipation, portal stagnation, chronic gastro-enteritis, chronic respiratory, pelvic, and rheumatic conditions

Alkalis—The alkaline waters increase the alkalinity of the blood plasma, promote tissue changes, increase metabolism, and tend also to increase the alkalinity of the urine As alkalinity promotes the action of the saliva, bile, pancreatic, and intestinal juices alkalis enhance digestion Alkalis are alleged to facilitate respiration (Voit) not only in the tissues, but also in the lungs, by acting as carbonic acid carriers The alkaline waters are used in acid dyspepsia, constipation, gall stones gravel, gout, glycosuria, and obesity

morbid process, but also may so tone the weakened heart that edema, pain and breathlessness disappear and then by carefully regulated training the circulatory system may be further strengthened so that even under considerable exertion the heart acts strongly, regularly and without embarrassment.

In chronic diseases of a less hopeful degree spas afford relief from the weariness and monotony of prolonged home treatment New surroundings, new physicians, new therapeutic measures seldom fail to relieve the depression, and they enhance the vitality of chronic invalids

There remain a few pas which are merely bath houses,' but the modern spa is in the truest sense a health resort Spa therapy is not confined to baths diets and exercise Drugs and every measure which can combat disease are utilized sometimes even to the exclusion of hydrotherapy Thus, at Clifton Springs near Rochester New York, the spa is organized under the able direction of Dr M S Woodbury into departments of internal medicine, neurology surgery and pathology Hydrotherapy balneology, electrotherapy physical training and industrial therapeutics are all used there as adjuvants to rational treatment This excellent institution is operated under a trust deed which requires that all receipts in excess of expenses be devoted to improving the institution and to the care of patients at reduced or free rates In other spas such as Hot Springs, Arkansas the American Aix la Chapelle and Mount Clemens Michigan, the main endeavor is to enhance the efficacy of drug treatment of disease In these last two institutions unrivaled facilities for the treatment of syphilis exist The administration of mercury by expert rubbers in a careful systematic and thorough fashion insures as far as is humanly possible freedom from the dread sequelæ of this disease and mitigates or removes such symptoms as may arise The absorption and elimination of the mercury is aided by bathing The treatment is not confined to mercurial inunctions arsphenamine and other drugs are also used in appropriate cases Particularly happy results are attained in the nervous manifestations of syphilis in which the physical therapy relieves pain promotes nutrition and strengthens the musculature while the drug treatment attacks the essential cause of the malady

All chronic diseases except a few such as epilepsy and tuberculosis whose victims may be undesirable associates for other sufferers are treated at spas Some spas, however because of their situation or because of the character of their waters are traditionally efficacious in the treatment of special diseases Thus at Kreuznach Woodhall and Kissingen exudates from chronic endometritis perimetritis and salpingitis are said to disappear, even fibroids have been alleged to melt before the solvent action of these waters At Mannheim and at Rheine cardiac and joint sequelæ of rheumatic fever are cured Schlangenbad is especially lauded for the relief of the neuralgia which so often follows influenza and malaria, the

which they retire from the monotony of family and social life, and in which hygienic, dietetic, and medical discipline provides them with an excuse and with an opportunity for cure

For tardy convalescence the spa is eminently desirable but not always necessary In many cases, as in chlorosis, change, alone, is needed The anemic country girl visits a town and quickly improves The anemic town girl returns rosy from the sea, the moors, or the mountains The new regime and environment are sufficient to bring about the desired cure In other cases the chief factors of benefit in the change are fresh air and exercise for such the locality chosen should have a slight rainfall in order to insure the possibility of outdoor life, the temperature is less important, for appropriate clothing and exercise will maintain the body heat But the value of warmth in winter, to those convalescing from painful nervous and rheumatic conditions, and of coolness in the summer to invalids from hot stuffy towns, is too well known to need emphasis But when a change is imperative and medical care is still necessary the patient should be sent to a spa Good sanitation, comfortable quarters, and constant care can there be relied upon If a special climate be also desired, all climates are available to the fortunate residents of the United States, and there also is a choice of many different kinds of spas at the same latitude

But the main sphere of the spa is the treatment of chronic diseases. In the metabolic diseases the eliminating channels are cleansed and maintained clean by the ingestion of the mineral waters and by bathing dietetic discipline is enforced, so auto-intoxication ceases, physical therapy is practiced which together with the radio-activity of the waters, promotes oxidation The control of the bulk of the food and the regular emptying of the alimentary canal enables the weak and overstretched muscles of the stomach and bowel to renew their tone Massage for the feeble and for those in pain, passive movements, regulated either by masseurs or by the ingenious mechanical appliances of Zander, active movements, in the recumbent posture for the weak, walking carefully controlled distances on level surfaces, or—for the stronger—up measured slopes, and finally, gymnastic practice swimming tennis, golf and other outdoor sports,—these means strengthen feeble cardiac and vascular muscles, tone the flabby voluntary muscles and promote the circulatory, digestive and mental processes

Under suitable treatment by baths, mineral waters, diet and physical exercises, metabolism is thus quickened, obesity is reduced, deposits diminish around thickened joints and in infiltrated muscles, pain, therefore, is alleviated, movement returns and wasted muscles recover Diseased kidneys are rested and their work is lightened to their power to function properly

In cardiovascular diseases such treatment not only may arrest the

tuted by the private physician, then a home spa may be utilized in order to strengthen the patient for the long rough journey, or the stormy sea voyage, or the rigors of the new climate and then the possibly more desirable and efficacious foreign spa is attempted. Thus in severe heart cases a modified Nauheim treatment may first be instituted by the private physician, then a home spa may be utilized in order to strengthen the patient for the long rough journey or the stormy sea voyage, or the rigors of the new climate, and then the possibly more desirable and efficacious foreign spa is attempted.

Climate of Spa.—As regards the climate raw damp cold regions would naturally be contra indicated in acute pulmonary conditions or in convalescence from pneumonia. High altitudes while dry and rare and calm, afford greater variations of temperature and are not desirable for the sleepless and mentally distressed nor should they be visited by severe heart cases, arteriosclerotics, apoplectics and those with a tendency to hemoptysis. Then convalescents from acute diseases also had better not be sent to mountainous health resorts. For all these the sea level is better, for the sea climate is more equable.

The Spa Itself.—The chemical composition of the water is not a matter of great moment. More important are the bathing facilities the provision for physicotherapy and the housing arrangements. Unless good food and good accommodation are insured the spa should be avoided. For the slightly ill the social life of the spa is an important therapeutic factor. But the most essential point of all in the choice of a spa is a knowledge of the medical skill available. A spa where a local physician is personally known to the physician who sends the case should if possible, be selected. Just as a physician would not readily recommend his patient to a surgeon for whom he could not personally vouch, so should he be chary of committing his case to the care of an unknown health resort physician. Arrangements for the patient should be made before the journey is commenced so that when the invalid arrives at the spa all unnecessary discomfort and delay may be avoided. With the patient a full account of his malady and its treatment should be sent. Much must be left to the discretion of the local physician at the health resort, but the family physician should know whatever is proposed for the treatment of the patient he sends why it is proposed and what it promises. Home spas should always be recommended whenever possible. The season at most spas is from May 1 till September 30. Many, however, especially those with thermal springs, are winter resorts also.

Tardy Convalescence

A patient convalescing is in a state of physical and mental instability and has so little reserve strength that fatiguing journeys must be avoided

obese and the gouty are catered for at Carlsbad and Marienbad, the syphilitic, at Aix la Chapelle, and so forth This specialization is of great value Every facility which science has devised for the treatment of the selected disease is provided at the spa The spa physicians have a vast experience of these special ailments and great skill in their treatment, and the competition for health among the similarly sick at such spas is of considerable therapeutic value Hence these spas often confer a more rapid, a greater, and a more permanent improvement than home treatment can attain

American spas are not yet specialized as European spas At Glen Springs New York, particular care is given to cardiovascular diseases. The Nauheim spring is rich in calcium chlorid, and its brine is five times more concentrated than that of Bad Nauheim Springs at Saratoga are so numerous and so diverse in composition that the waters are especially suited for the treatment of many maladies, among which stress is laid upon digestive disorders, chronic rheumatism and sciatica The excellent work of Dr Charles G Anthony in supersaturating the Nauheim baths with carbonic acid gas makes them unequaled At Virginia Hot Springs, the American Aix les Bains, special study is given to metabolic diseases The hot baths and the genial climate are grateful in myositis, sciatica, neuritis and rheumatoid conditions, and the radio-activity of the waters enhances their value At these springs there is an excellent installation of Lander apparatus and physical therapy is well organized White Sulphur Springs, one of the most luminous health resorts in the world, has a splendid climate, and excellent bathing facilities Waukesha Springs Wisconsin, is given up to the treatment of severe functional disorders of the nervous system

War has made European spas inaccessible at present, and the residual hatred among the belligerents will long deprive the German and Austrian spas of much of their cosmopolitan charm In the meantime the wealth of balneological resources which the United States possesses is slowly being realized by Americans The authorities have begun to conserve this wealth the patients to appreciate it Foreign spas offer no therapeutic facilities which cannot be equally obtained, both more easily and more comfortably, by Americans at home

Unless the patient's physical state warrants the strain of a journey the suggestion of a spa should not be made Having determined that a spa is desirable, the physician considers the accessibility of the spa, its climate, its elevation above sea level, the accommodation it provide, the nature of the waters, the bathing, massaging, and other therapeutic facilities, and above all the quality of the medical care available These considerations determine his choice In weakly patients a preliminary course of treatment may be necessary at home before any journey is attempted Thus, in severe heart cases, a modified Nauheim treatment may first be insti

Cardiac Diseases—With cardiac cases careful consideration is imperative before a visit to a spa be attempted. In severe valvular conditions the patient is better at home. Long journeys and bulky water treatment are more liable to kill than to cure. If spa treatment be contemplated in such cases a preliminary course of Nauheim baths (see Chronic Myocardial Insufficiency) should be given at home. The heart muscle should also be strengthened by cardiac tonics such as strophanthus or digitalis. Even when the valvular disease or the myocardial change be not severe the journey should not be rashly undertaken and it is desirable to travel by short stages.

A beginning should be made with rest after the journey. Then Nauheim baths of short duration and about body temperature should be given. Gradually the baths may be cooled and lengthened. Then the carbonic acid gas may be added to them. Finally the Schott exercises may be attempted. Later the Oertl treatment, regulated walking and the climbing of slopes, may be practiced when the heart has been strengthened enough to allow of its use.

The hearts most benefited by spa treatment are the weak, fat, flabby hearts of overindulgence in everything except exercise.[4] The dietetic and hygienic regime and the graduated work often act as a charm in such cases. If the heart is weak, graduated exercises are very cautiously initiated. Passive movement alone is first attempted, next active movements, then resistance movements and finally the Oertl exercises. In the dilated fatty heart of anemia the cause of the anemia should be the chief object of treatment. The guiding principle should be 'to hasten slowly.' Excessive work may damage a dilated heart so as to require months of treatment to remedy the indiscretion. Very little good comes from the ingestion of water, and positive harm may accrue if the water be aerated.

Renal and Bladder Diseases—Since the work of von Noorden and his school the popularity of balneological treatment in kidney diseases has rapidly waned. It is now generally admitted that to fatigue the kidneys by imposing upon their already feeble energies the labor of excreting large quantities of fluid is a course of very doubtful therapeutic wisdom.

The cause of gravel lies in dietetic errors. No treatment should be instituted before the precise chemical composition of the urinary deposit is determined. *Then rational dietetic measures are the best means to combat the tendency.* To render the urine alkaline by ingestion of alkaline waters in bulk is to precipitate the urinary phosphates and to add a phosphatic layer to the calcareous nucleus already present. The

[4] The special indication for Nauheim treatment is chronic myocardial insufficiency of the first and second degree; it should never be employed in the third stage (see Chronic Myocardial Insufficiency).—EDITOR

All spas which practice heroic methods are emphatically contra indicated No "flushing" treatment to exhaust the heart and to fatigue the kidneys should be considered A change of air alone may be all that is necessary If a spa be selected it should be one in which the treatment is gentle and not fatiguing—a mild, near, warm, sheltered spa, at a low altitude If the patient is markedly anemic a spa with iron waters or with iron and salt waters should be chosen

SPECIAL BALNEOLOGY

Diseases of the Blood—*Anemia*—It is essential, first, to consider whether the patient be suffering from primary or secondary anemia In the primary anemia of adolescents constipation is so often a causative factor that good results are frequently obtained by the use of the mild aperient waters of any of the saline or thermal springs Such waters alone may effect a cure But before, during, and after the spa treatment pharmaceutical preparations of iron may be exhibited If a mixed salt and iron spring be available the treatment may be begun there and then finished at another spring containing more iron Often climatic change alone suffices to effect a cure, and no change is more generally useful than that which is obtainable by a sea voyage In the anemia which follows repeated losses of blood from hemorrhoids, the mildly purgative springs, which tend to reduce portal congestion, are indicated In the anemia due to chronic renal conditions, great care is necessary the diseased kidneys are already overstrained, the demand made upon them by the ingestion of a great volume of fluid may complete their undoing In the anemia of incipient tuberculosis, especially that complicated by hemoptysis, a warm, sheltered, low altitude spa is desirable In the anemia of syphilis, sulphur springs, such as Aix la Chapelle, are recommended *In all anemias* it is essential, first, to recognize the underlying cause and then to choose the spa suited to the treatment of the primary disease

Diseases of the Respiratory Organs—The main respiratory diseases seeking balneological treatment are chronic bronchitis and emphysema, asthma, and tuberculosis Persistent traces of exudate after pneumonia are also often subjected to spa treatment The essence of the treatment, so far as the respiratory tract is concerned, is to improve the climatic conditions Bronchitis and emphysema arise from many causes—respiratory, renal, cardiac, vascular, etc The cardiac and vascular, and perhaps the renal case, may be benefited by appropriate waters The slight expectorant action of the alkaline and saline waters may also directly help the relief of the morbid process in the lungs For the tuberculous patients rest, feeding, sun and light, and fresh air baths are necessary

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flushing of the urinary system with waters containing small amounts of calcium carbonate and phosphate—the so-called earthy waters—is in itself harmless and of little efficacy Equally good results could be obtained by drinking quantities of warm water on an empty stomach at home As the cause of calculus formation is usually disease of the bladder wall, local medicinal treatment of proven value must not be neglected for the more ornamental but less useful bath treatment

Rheumatism —No one would think of moving a case of acute rheumatism to any spa, however praiseworthy In the prolonged convalescence which follows sometimes, in cases which persistently relapse slightly, which continue to have tender, painful joints, which show slight valvular or myocardial changes, or which are pronouncedly anemic, a change to a spa often works wonders When joint changes are the main impediment to health, when thickening and effusion persist, a spa should be chosen with *alkaline or sulphurated saline waters*, a hot spa, a spa *in which Zander* exercises, massage, and good bathing facilities are obtainable, so that absorption of the morbid products may be hastened When cardiac trouble is the residue, then Glen Springs, Clifton, Saratoga or some other spa, where cardiac troubles are especially treated, should be selected The anemic cases should be sent to an iron saline spring The climate of the spa selected should be equable, warm, and dry

Alimentary Disorders —It is among the indiscreet of habit the people who work too much *and eat too little*, and those who eat too much and work too little, that the benefits of spa treatment are most pronounced In the dyspeptic, the gouty, the "livery," the spas find their most grateful patients The myriad of minor ailments of alimentary *origin*, and of importance in direct proportion to the neurotic and to the financial disposition of the patient, yield to the dietetic regulation of the spa The purgative waters clear the channels of life from accumulations of ages Constipation is not permitted the portal circulation is stimulated to activity hepatic congestion disappears, and piles and pelvic disorders are mitigated or banished The gouty concretions are dissolved, the system is flushed clean contributory dietetic errors are rectified, and the high specific *gravity of the urate loaded urine* is lowered

Much work requires yet to be done before we can have a satisfactory rational basis for the treatment of the lesser ailments Experience and experiment *guide us to send patients with atonic dyspepsia to* sources with hypertonic waters to send acid dyspeptics to the mildly alkaline saline springs, and to send the obese and the gouty to the sources of strong waters, such as Carlsbad and Marienbad After treatment *with* drastic catharsis, prolonged rest and judicious feeding are necessary If these cannot be obtained then less heroic measures should be used

After all spa treatment a rest in a bracing climate for several weeks is strongly to be advocated before recommencing the routine of life

CHAPTER XII

PRACTICAL APPLICATION OF COMBINED METHODS OF PHYSIOTHERAPY

HARRY EATON STEWART

DISEASES AND INJURIES OF THE NEUROMUSCULAR SYSTEM

CENTRAL MOTOR NEURON LESIONS

Birth Hemiplegia in Children—Birth injuries resulting in spastic paralysis and retarded mental development are treated best by prolonged and persistent reeducational gymnastics and massage Simple arm and foot placing coupled with controlled movements aimed at placing the finger upon the correctly colored or numbered squares, are often used Exercises of balance and slow bilateral coordination are very valuable Progress then to very simple games within the mental and physical power of the child to grasp and perform with reasonable accuracy Radiant light for ten minutes coupled with effleurage and gentle muscle kneading aids in keeping up the nutrition of the affected parts Accurate placing and controlled pressure with knife and fork are useful in preparing the child to serve himself at the table

Hemiplegia Following Cerebral Hemorrhage—From ten days to two weeks after the lesion has occurred or after there is reason to believe all bleeding has stopped the use of through and through diathermy by the interparietal route using 500 milliamperes of current of absolute steadiness will greatly aid in hastening the absorption of the clot Take five minutes slowly to increase to maximum maintain this for twenty minutes and use three minutes in reducing it slowly to zero On the affected part, use effleurage on the flexors petrissage and effleurage on the extensors High frequency surface applications, or diathermy from hand to shoulder and foot to hip will aid in relaxing the spasticity Reeducational exercises with slowly and carefully coordinated and controlled movements should be employed from the third week Some very good results have been obtained with men at St Elizabeth s Hospital at Washington and other places by introducing games such as indoor baseball and volley

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with slight effort, a rather wide range of motion on polished or smooth wooden surface (see Exercises with Carriage)

Passive Exercises

Normal movements of each main joint of the affected part should be carefully carried out. Extreme caution should be used not to overextend muscles or muscle groups already at a physiological disadvantage and

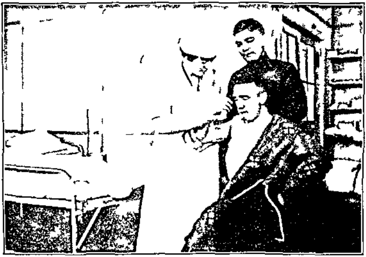

Fig 1—Passive Extension of Shoulder Joint

tending to be stretched by their less affected physiological opponents as is often the case with the Tibialis anticus. Those groups tending toward contracture should be stretched several times to their physiological limit. The plantar and calf muscle groups usually require this care.

Exercises with Carriage

Arm

Patient on chair affected side toward the table

1 Abduction and adduction of arm

2 Flexion and extension of elbow

3 Abduction and adduction of the arm with movement arrested at different points and starting again

4 Small circles to the left and to the right by combined movements of elbow and shoulder

5 Have the patient lean forward so as to bring the arm in the same plane as the body using large sweeping movements from the shoulder

ball A surprising amount of motor activity is often regained and the patient completely forgets himself in his interest in the game The sinusoidal or faradic current may be sparingly employed to obtain muscular contraction and encourage the patient to voluntary muscular effort where active motion is impossible Assistive movements should be stressed, insisting upon the conscious motor effort on the part of the patient, even though his response to such effort is almost nil

Cerebral Degeneration—Impaired brain nutrition due to arteriosclerosis may at the beginning be retarded and to some extent improved Cerebral diathermy may be used by applying the electrodes to the forehead and occiput Gentle, long-continued cerebral galvanism through water resistance has also been successful in treating these cases Mild, general massage is a useful adjunct in improving general nutrition Carefully graded general exercise is valuable

Encephalitis Lethargica—In the convalescent stage of this disease recovery of function may be hastened by massage and exercise, employing general petrissage and effleurage General calisthenics and carefully graded mild exercises may be used The spasticity of any muscle group is treated by radiant light and high frequency

Cord Lesions—Infantile Paralysis—After the acute stage has passed and all tenderness has disappeared from the muscles, persistent and long-continued physiotherapy is indicated A reasonable degree of success has been attained through treatment by the separate use of several types of physiotherapy, but it has been clearly demonstrated that the properly combined use of different measures is much more satisfactory Radiant light and regional diathermy are used to warm and prepare the part for massage and exercise The paraffin bath or whirlpool bath may be substituted for radiant light Diathermy or high frequency are invaluable aids in inducing the deep hyperemia which improves the nutrition of the muscles Massage should be confined largely to petrissage and be stimulating in type, but *not* too long continued Care must be taken to direct the effort to the muscle groups The thick, fatty, fibrous layer, which so often overlies the muscles, may receive the major portion of the effect of the massage, if superficially given Before voluntary motor responses are possible, the sinusoidal wave galvanic, or interrupted galvanic current may be used In muscle groups supplied by partly regenerated neurons a fair response may be obtained by faradism, but the early institution of voluntary movement is especially desirable Muscular contraction by means of carefully graded exercise is, as a rule, to be preferred to that obtained by electricity If the age of the child permits, his active mental effort should accompany each passive movement, making it really assistive in type These exercises should at first be performed, as far as possible, in a plane at right angles to gravity A small block of wood upon which the hand or foot is strapped, supported by castors, will permit,

RESISTIVE EXERCISES

Arm

1 Flexion and extension of fingers resisted finger to finger by the operator

FIG 2—PRONATION AND SUPINATION MACHINE

2 With glove the fingers of which are counterweighted extension with hands prone, flexion with hand supine
3 Finger flexion machine
4 Finger treadmill

Wrist

1 Flexion and extension abduction and adduction resisted by operator
2 Wrist roller machine

6 Hand prone on carriage, abduction and adduction of the wrist
7 Hand with ulnar side on carriage, flexion and extension of wrist.

Leg

1 Patient supine, heel on carriage, abduction and adduction of the leg
2 Patient on unaffected side, unaffected leg flexed, internal malleolus on carriage, flexion and extension of knee
3 Position same—flexion and extension of hip

Free Exercises

Arm

Patient lying supine on broad table or floor, exercises bilateral to improve coordination Starting position, hands to the side
1 Bring hands on hips and return
2 Raise forearms to vertical and return
3 Carry arms to complete abduction and return
4 Raise arms fore upward, carry to above head and return
5 Carry arms across body and return
6 Bring hands sharply to shoulder and return
7 Carry arms to full abduction, bring hands to axilla by flexing elbows, extend elbows and adduct arms
8 Supinate and pronate the forearm

Leg

Patient on unaffected side
1 Flex and extend ankle
2 Flex and extend knee
3 Flex and extend hip
Patient prone
Abduction and adduction of leg with knee semiflexed, rotate hip inward and outward

Back and Hip Extensors

1 Patient sitting hands on hips incline trunk forward and raise to vertical Progression secured by increasing the degree of forward inclination of the trunk and by placing hands behind the neck or over head
2 Patient prone on table, feet strapped, raise backward and lower Hands behind neck or extended over head increase the difficulty of this exercise

In summarizing the treatment of Infantile Paralysis the following points should be kept in mind Many spinal motor neurons not entirely destroyed may be stimulated to function years after the acute attack Work on injured tissue of this type is a delicate task which should not be entrusted to the untrained The danger of overfatiguing these weakened structures is constant Exercise as nearly as possible active in type is better than electrically inducing contractions and both types should never be combined at one treatment Two or three movements of each type are sufficient at first, and the increase in amount should be very gradual indeed

Peripheral Nerve Lesions

Muscle Nerve Testing —Reactions of nerve and muscle become greatly altered in their response to electrical stimulation when any pathological condition is present Electrical testing supplies us with most of our data for diagnosis in nerve conditions and is a most important process, giving information that cannot be gained in any other way The technic of nerve and muscle testing should be thoroughly understood and considerable practice is necessary before one becomes proficient

The faradic and interrupted galvanic currents in turn are used in testing both the muscle and the nerve that supplies the muscle The normal muscle responds to faradism by tetanus, as the interruptions to this current are so continuous in character that the muscle does not have a chance to relax between stimuli When the motor nerves are affected by disease or trauma they lose their normal response to faradic current in fact, under certain conditions this current has no power to evoke any response whatever The response to galvanic current however is a twitch produced when the current is made or the circuit is closed and a slighter twitch when the circuit is broken greatest at the cathode Such are the normal reactions of nerve and muscle to these currents

The changes in response to electrical stimulation which follow trauma by cutting crushing or pinching or inflammatory processes of the motor peripheral nerve or its sheath are termed reaction of degeneration This reaction of degeneration or R D is characterized by

1 Loss of faradic excitability
2 The following changes in the responses to interrupted galvanism
   a Response is sluggish and wavelike in character
   b The motor point is lost
   c The polarity response is inverted that is instead of the muscle twitch being greatest at the cathode when the circuit is closed or made it is equally great or greater at the anode changing the normal formula $KCC > ACC$ to $KCC = ACC$ or $ACC > KCC$

Elbow

1 Pronation and supination, flexion and extension resisted by the operator
2 Pronation and supination machine
3 Flexion and extension of elbow with pulley weight machine

FIG 3—RESISTIVE EXERCISES FOR DEVELOPMENT OF LEG STUMP

Shoulder

1 Operator behind patient, resisting abduction and adduction of the arm
2 Arms raised forward, operator resisting and carrying of arms sideward and forward

Leg

1 Operator grasps dorsum of the foot with one hand and heel with the other and resists flexion and extension of the ankle
2 Grasp with one hand above the knee and the other around the foot, resist flexion and extension of the knee and hip
3 With grasp of the ankle resist abduction and adduction of the hip

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These changes begin in a muscle, the nerve supply of which is interfered with from eight days to three weeks after the injury or disease has occurred, and become progressively greater in degree. In the normal muscle the chronaxie or contraction time is very brief and the muscle will respond to a stimulation of 1/2,400 of a second at 100 volts. Progressively longer and greater stimuli are required if degeneration progresses, until, with one lasting 1/200 of a second, it may not be possible to obtain a contraction. The reaction of degeneration is a sign of marked value to us in that it may indicate the location of the lesion, and stage of its

FIG 4.—MEASURING THE STRENGTH OF THE MUSCLES COVERING ELBOW EXTENSION IN A FOREARM AMPUTATION CASE.

development. R. D. is never present in a central motor neuron lesion. When there has been a contusion or cutting injury to some, but not all of the fibers, or they have been subjected to a mild amount of pressure, a condition known as partial reaction of degeneration may occur. This condition is characterized by weakened responses to faradism, a slower response to galvanism, a dulling of the motor point and a diminution in the normal differences of polar response. In the stage of regeneration, voluntary motion often precedes the return of faradic excitability and a gradual change to normal takes place during a period of months. The surgical indications for nerve suture, neuroma or dense cicatricial excision or freeing a nerve caught in callus must be followed if physiotherapy is to be effective in shortening the disability time.

Apparatus and Technic.—The muscle should first be tested with faradism, using a large indifferent and a small active electrode, care being taken not to use an amount of current which will "splash through" to neighboring unaffected muscles. The corresponding muscles on the normal limb or on the operator may be used for control. The test with interrupted galvanism is most satisfactory when done by means of the muscle testing condenser. This is a modification of the Lewis Jones apparatus consisting of a series of galvanic condensers, of ascending microfarad capacity, equipped with an interrupter on the machine. The current is delivered at a strength of about 100 volts which is sufficient to overcome the resistance of the properly moistened skin. A scale varying from .01 to 2 microfarads is available on this machine.

Some preliminary warming of the part is desirable before testing. Radiant light and heat or the whirlpool or paraffin bath may be used for this purpose. Diathermy, while aiding distinctly in the nutrition of the part and the regeneration of the nerve and muscle, will quite badly mask the results of muscle testing; hence it should be used *after* and not before such tests are to be made. With the use of the condenser, the normal side also is taken as a control. The active, testing electrode should be not over one-half inch in diameter and for the interossei and finer muscles must be even smaller. It is attached to the negative pole and applied as nearly as possible to the motor point. One condenser after another is turned on and the point noted at which a good response in muscle or tendon is elicited. A convenient chart for recording results of the test, as used by Captain A. B. Hirsh at Walter Reed Hospital, is appended. Occasionally in large masses of scar tissue the motor point may be displaced, but it is easily located with the condenser. It was found at Walter Reed Hospital that the test made with the condenser checked up well with conditions found at operation. Muscles which respond somewhat to faradism will usually recover within six weeks, but a guarded prognosis should be made in regard to ultimate recovery.

	Faradic L P	Galvanic L P		
Musculocutaneous				
Peroneus Longus				
Muscles Extending Tarsus and Flexing Digits				
Tibialis Posticus				
Gastrocnemius inner head			Name	
Gastrocnemius outer head				
Tibialis posticus			Ward	Date
Flexor longus hallucis			Tested by	
Flexor longus digitorum			Recorded by	
Flexor brevis digitorum			Diagnosis	
Interossei			Department No	
			Remarks	

Faradic L P — Galvanic L R

Muscles Acting on Humerus
Superascapular
- Supra spinatus
- Infraspinatus

Musculocutaneous

Circumflex
- Deltoid
- Teres minor

Muscles Acting on Forearm
Musculocutaneous
- Biceps

Musculospiral
- Supinator longus
- Triceps

Muscles Causing Pronation

Median
- Pronator teres
- Pronator quadratus

Muscles Causing Flexion
Median
- Flexor carpi radialis
- Palmaris longus
- Flexor sublimis digitorum
- Flexor longus pollicis
- Abductor pollicis

Ulnar
- Flexor carpi ulnaris
- Flexor profundus digitorum
- Hypothenar group
- Flexor brevis pollicis (median)
- Adductor pollicis

Muscles Causing Extension
Musculospinal
- Extensor carpi radialis longior
- Extensor carpi radialis brevior
- Extensor ossis metacarpi pollicis
- Extensor longus pollicis
- Extensor communis digitorum
- Extensor carpi ulnaris

Muscles Acting Between Fingers
Ulnar
- Interossei
- (2 Outer Median)

Muscles Acting on Femur

Obturator
- *Adductor longus*
- Adductor magnus (sciatic)
- Gracilis

Superior Gluteal
- Tensor vaginæ femoris

Muscles Acting on Tibia
Anterior Crural
- Vastus internus
- Vastus externus

Sciatic
- Biceps
- Semitendinosus
- Semimembranosus

Muscles Flexing Tarsus and Extending Digits

Anterior Tibial
- Tibialis anticus
- Extensor longus digitorum
- Extensor proprius hallucis

Electrical Diagnosis at Operation.—Crane and Ingham used electrical testing during operations at the Cape May and Fox Hills Army Hospitals to identify and determine the condition of exposed nerves. The nerve was picked up on a curved glass rod and tested with only sufficient strength to produce a minimum muscle contraction. Tests were made above and below the lesion. Information of great surgical importance may be obtained in this manner.

Treatment of Peripheral Nerve Injuries.—Great care must be exercised not to overstimulate regenerating nerves. Our efforts should be

directed to maintaining, as far as possible the nutrition and tone of muscles whose nerve supply has been interfered with. Radiant light and heat and gentle massage are useful in this respect. Treatment by means of diathermy which, as before stated, interferes with muscle testing is a most valuable part of the regime. It is now believed that a good deal of the atrophy which ensues in muscles whose nerve supply is subnormal is due not to inactivity but to overactivity caused by a fibrillation of the individual muscle fibers. In several cases of severe peripheral neuritis due to beriberi this fibrillation was coarse enough to be seen. The effect of the high frequency currents, particularly the

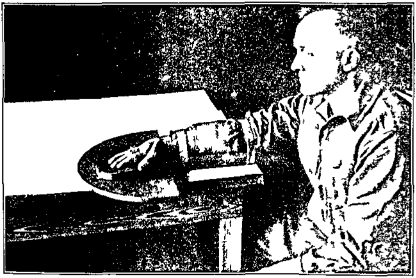

FIG. 5.—APPARATUS FOR MEASURING DEGREE OF RETURN IN JOINT FUNCTION

d'Arsonval in producing sedation and arresting fibrillation is marked. It is perhaps as much through this effect as that of local vasodilatation that diathermy has proved so useful in these conditions. The electrical stimulation of contraction has often been overdone and a carefully graded technic such as that used by Sampson and described in the section on Sinusoidal Currents is all that should be used. Overstimulation will defeat the aim of early regeneration and delay recovery.

Passive motion should be maintained in all the joints moved by the affected muscles and protective braces are essential to prevent contractures. Progress to assistive and active exercises as returning enervation permits. Carefully prescribed occupational therapy should be used coincident with physiotherapy as soon as some active motion and strength are secured.

FARADIC GALVANIC

L P *L R*

Muscles Acting on Humerus
Superascapular
- Suspraspinatus
- Infraspinatus

Musculocutaneous

Circumflex
- Deltoid
- Teres minor

Muscles Acting on Forearm
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- Pronator quadratus

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Muscles Acting on Tibia
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hould be placed along the affected side of the lower cervical vertebræ, the other may be a cuff above the elbow or the autocondensation handle held in the hand depending upon whether or not the pain radiates below the elbow The electrode for Morton wave is applied along the upper border of the trapezius muscles to include the exit of the circumflex nerve. Static brush and sparks may be used freely over the entire painful area

Sciatic Neuritis—The technic of the electrode application for ionization or positive galvanism is described under ionization The radiant light should be applied from the sacrum to below the knee A long narrow electrode extending from the sciatic notch to the popliteal space is used for the Morton wave application while sparks are applied throughout the origin and course of the sciatic nerve There is a steady progression in the vigor of the treatment from the subacute through the chronic stage Chronic cases are often temporarily rendered acute after which they clear up more readily and the patient should be so informed

Neurasthenia—The number of diagnoses of pure neurasthenia is decreasing Some organic basis for the symptom-complex termed "neurasthenia is now usually found and yet whatever the cause there are certain tonic treatments of a physical type which will in most cases hasten recovery Those cases associated with low blood pressure are treated by static charge spinal vibration increasingly vigorous massage and general exercises There has been described a splanchnic type in which due to poor vasomotor tone of the splanchnic veins the systolic blood pressure is higher in a horizontal than in a sitting or standing position These cases seem to be benefited by the type of treatment just given and an improvement in their general condition is coincident with a return to normal in the blood pressure variations in the different positions of the body

In cases complicated by anemia and sluggish intestinal action, general progressive body raying with the ultraviolet light and special abdominal massage and exercises with Morton wave current over the liver are indicated

The tonic type of hydrotherapy especially short cabinet bath followed by Scotch douche with increasing variation of hot and cold is very useful

It is justifiable to employ the psychical effect of the electrical modalities, when carefully chosen as well as for definite physical effect

Toxic Myositis—In the *acute* stage relief is obtained by prolonged local heat, radiant light of high candle-power or superheated dry air followed by direct diathermy or surface high frequency static effluve or mild static sparks and Morton wave with massage consisting of petrissage and gentle deep kneading

In the *chronic* stage diathermy should be pushed to tolerance Long heavy sparks and Morton wave or the long stroke motor vibrator should follow diathermy A surging sinusoidal current may be to some extent

Neuroma—The warm whirlpool or paraffin bath, diathermy, and occasionally, positive galvanism, are useful in allaying pain The cure of it is distinctly a surgical problem

Neuralgia—Prolonged intense radiant light and heat, diathermy localized over the affected nerve and static effluve will often relieve this condition All treatments should be long continued and gentle in type

Volkmann's Contracture—Good results were obtained in many of our army cases by the persistent use of physiotherapy Radiant light and heat or the whirlpool bath, as hot as could be borne, were used for about ten minutes followed by zone or through and through diathermy The massage should consist of effleurage, light kneading and passive movements The fingers should be straightened with the wrist flexed and held in this position while the attempt is made to extend the wrist

Acute Neuritis—In either the toxic or traumatic type of acute neuritis, a good general technic is as follows Radiant light and heat, 1,500 candle-power for twenty minutes Direct or zone diathermy 1,000 to 1 500 milliamperes for twenty minutes followed by ten minutes of static effluve If tender points are found, the diathermy and static brush should be localized as nearly as possible over them Special care should be taken in going over the spinal nerve roots which supply the affected area to elicit tenderness

Snow uses static Morton wave, starting with a short, easily tolerated spark gap *which is widened as further tolerance is developed* In my hands this procedure has occasionally been very successful but often has increased the severity of the pain

Another technic, employing ionization with sodium salicylate, has been described in the section on that modality

Frank B Granger, of Boston, has attained good results with a combination of prolonged ionization or positive galvanism, together with vibration to numbness of the affected spinal nerve roots In this technic the solid rubber ball vibratode is applied to the intervertebral spaces on the affected side, at least one minute over each nerve root If too short a vibration is given, the tendency is to stimulate instead of to numb the pain

Static sparks may be used to relax associated muscle spasm but are more valuable in chronic neuritis

Chronic Neuritis—Preliminary heat and diathermy should be followed by static Morton wave and sparks, after which slow deep effleurage along the nerve trunk for several minutes should be given. Sparks or sinusoidal current may be used freely to relieve the spasticity of neighboring muscles Ionization and positive galvanism are not as efficient in chronic as in acute neuritis

Brachial Neuritis—Radiant light and heat should be applied to the nerve roots as well as to the shoulder and arm One diathermy electrode

DISEASES AND INJURIES OF THE BONES AND JOINTS

Fractures—The treatment of fractures has been mentioned as one of the exceptional conditions in which the usual surgical procedures are modified when physiotherapy is applied. This is in reference to the retention of fixation apparatus. The best results are obtained when open fixation or bivalved casts, which may be early removed and replaced, are used. There is always trauma to the surrounding soft parts to which the application of physiotherapy is highly desirable, while the continued mobilization of surrounding joints is an essential feature of good fracture work. The actual healing time of the fragments themselves may be reduced fully one-third. In cases of delayed union lasting many months, callus has been, for the first time, thrown out after the use of physiotherapy. Complications such as osteomyelitis may usually be effectively treated. Far better results follow a régime of preoperative physiotherapy after extensive injury to soft tissue where an open operation is necessitated. John T. Morehead of New York emphasizes the use of massage the day following reduction and passive motion instituted as soon as possible after the third day.

Simple Fractures.—Radiant light and heat is an aid to nutrition and to the relief of pain and may be started immediately with gentle effleurage. These two measures have been extremely useful where pain and muscle spasm rendered reduction difficult. Very short static sparks and effluve may be employed for the same purpose. As soon as all tendency to capillary oozing has ceased, a through and through sedative diathermy technic should be used. This consists in giving about 500 milliamperes for forty minutes daily. Zone diathermy through a tightly fitting and undivided cast may induce increased swelling and symptoms of pressure. It may be used above and below a splint or loose cast, but the direct method is to be preferred where possible. Static effluve is useful in relieving both pain and swelling. With the fragments firmly supported, gentle passive motion of the joints above and below the fracture should be started early and continued until active motion is possible.

As soon as callus union is obtained, more vigorous massage, including deep petrissage and friction, should be used. Active motion is one of the most valuable measures and must be started at the earliest possible moment. Distal joints should be actively exercised from the start. Colonel Dean in his work with the British Army demonstrated the great value of active exercise. Should joint adhesions form, the use of the patient's body weight may often be employed to stretch them instead of depending upon the manual passive exercise. The breaking up of adhesions by violent passive motion under an anesthetic is almost never necessary or advisable.

substituted for static Massage includes tapotement, deep friction and kneading the object of these procedures being to relax the muscle spasm and mechanically remove the accumulated toxins Effort is made to institute a greatly increased active hyperemia and then force the excess circulation out of the muscles, bringing about a complete change of circulation and depleting the toxins and detritus

Traumatic Acute Myositis—These injuries are typified by the smashing muscle bruises received by football players and the remarkable efficiency of early and persistent physiotherapy has been demonstrated in a very large number of cases

The treatment of mild injuries without much tearing of muscle fibers, should be begun at once or within a few hours Fifteen hundred candle-power radiant light, paraffin bath, steam towels, superheated dry air or hot water may be used for external heat, mentioned in order of preferences Direct through and through diathermy, 1,500 to 2,000 milliamperes for fifteen minutes, should be followed by Morton wave static sparks or gentle slow, sinusoidal contractions of the involved muscles It is of the greatest importance to remove the exudate from the muscles before it has had an opportunity to organize

Treatment of *severe bruises* which are associated with tears of the muscle fibers should be postponed a few hours, until all capillary bleeding has ceased The Morton wave or sparks should be given very gently, if at all on the first day Massage should be directed the first day toward clearing out the lymphatics proximal to the lesion and not over the torn muscle fibers The second and third treatments should be quite vigorous in regard to these measures

Torn Muscle Insertions—These injuries follow sudden violent exertions, such as those used by the sprinter The muscles must be completely relaxed in extension before the application of physiotherapy External heat, direct or modified diathermy, by the combined use of autocondensation cushion and surface non vacuum electrode may be applied Static effluve is valuable in relieving pain and gently depleting the tissue fluids No other type of static or contractile current of any kind should be used until the muscle attachment is again secure Gentle, long-continued effluve will relax spasm, alleviate pain and remove lymphatic stasis

Tenosynovitis—This condition is most commonly found in the Achilles' tendon but sometimes elsewhere Acute cases require absolute rest and superficial heat, of the kinds mentioned Powerful radiant light or paraffin bath are best, or static effluve and tiny sparks, followed by finger tip effleurage may be used In chronic cases, the local heat should be intensified and longer sparks or vibration may be used to free adhesions between tendon and sheath and to break up and absorb any organized exudate that may be present Further massage consists of frictions and effluve

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In fractures near or into joints early mobility is being increasingly insisted upon. When, however, this is not possible, the muscle tone may be maintained by *the use of the slow sinusoidal, faradic or galvanic wave* currents. Very gentle contractions may be produced in individual muscles which will not involve joint movements.

Exuberant callus may be absorbed by the use of short intensive *diathermy treatments. Use small plates and push the heat to tolerance.* Great care must be taken if the area is anesthetic. Frictions and vibrations are additional aids in callus absorption.

Compound Comminuted Fractures.—This type constitutes a very large group in our army practice. The early use of prolonged radiant light and ultraviolet light directly on the wound is very valuable in controlling the amount of infection. Diathermy should be used by the double cuff method from the start. Slight motion of the fragments, produced by treatment, may not be detrimental. Later on, persistent sinuses may be treated directly by ultraviolet light with the water-cooled lamp through the use of sinus applicators. Massage has often brought to the surface a small and unsuspected sequestrum and it is useful for increasing tissue drainage when gently applied.

Fractures in children complicated by rickets are treated by local and general ultraviolet light in addition to the other forms of physiotherapy.

Fracture Sprains.—The linear fractures and small separations of bony tubercles that occur so commonly with severe sprains are better protected but otherwise treated by the technic for sprains later to be described. Where possible early active movement should be insisted upon.

Rickets.—If there is one specific use in physiotherapy it is the use of *ultraviolet light in this condition.* The work of Hess of New York, Erlacher, of Vienna, and many others shows that this method of treatment alone is sufficient to cure a large majority of the cases. Heliotherapy unfiltered through glass may be substituted for the quartz light. Treat*ment should be given daily to half of the body, the* initial dose depending upon the type of lamp and individual skin reaction, by the principles already outlined. The average dose is one to three minutes at thirty inches, with a ten to twenty second daily increment. Periodic X-rays *should be taken to estimate the degree of* calcification. Two months is usually sufficient for restoration to a practically normal picture, in cases not too far advanced. Where quartz light is not available, heliotherapy should be substituted and radiant light and massage may be used in conjunction with the changes in diet and medicinal care.

Osteomyelitis.—The work of A. B. Hirsh and C. M. Sampson, at the Fox Hills Army Hospital, demonstrated the value of diathermy and ultraviolet light in all types of osteomyelitis. The through and through diathermy, with technic arranged to concentrate the heat in the affected area, is the best type, where its use is possible. The double cuff or cuff

and water method may be used where the direct double plate technic is impossible. The active hyperemia induced in the seat of the lesion is a powerful aid in arresting the infection. General ultraviolet light should be used, preceded by high candle power irradiation to increase the skin capillary hyperemia, thus augmenting the volume of the blood stream acted upon by the rays, for the purpose of building up the general resistance. Local applications of quartz light are given if the location of the infection is fairly superficial. A large surface quartz applicator is used with compression. Deeper seated lesions with discharging sinuses may sometimes be reached through special applicators with the water cooled light.

Tuberculous Osteitis.—General ultraviolet irradiation is always indicated in tubercular bone disease. Local applications are useful if the lesion is sufficiently superficial to be reached by compression. The employment of diathermy will increase the phagocytes where most needed and its method of application depends upon the location of the process.

Periostitis.—Simple periostitis is treated with radiant light and heat or paraffin bath followed by high frequency static effluve and gentle effleurage. When periostitis is complicated with spur formation as is common in the os calcis the inflammatory process and consequent disability may be greatly relieved. Occasionally newly formed spurs may be to some extent absorbed. There is often little correlation between the size of spurs and the physical discomfort they produce. Intensive external heat is used if the process is superficial. If deep seated give direct diathermy with heat localized by using a small plate over the lesion. Static sparks sometimes greatly relieve the pain and are used after diathermy.

Traumatic Arthritis.—This type of injury is especially amenable to treatment by physiotherapy. In the acute stage where there is practically no rupture of ligaments active hyperemia may be induced by the hot paraffin or whirlpool bath, strong radiant light, high frequency or diathermy. This should be followed by static sparks directed not only around the joint surfaces but to such muscles as may be in a state of protective spasm proximal to the sprain. This is followed by prolonged gentle massage employing for the most part frictions and effleurage carried well above the injured joint.

Active use of the joint protected against stretching of the affected ligaments, is indicated from the start. The results of thorough and immediate treatment by this technic are extremely satisfactory. In severe sprains associated with extensive laceration of ligaments intensive local external heat is indicated followed by static effluve and gentle effleurage, the main effort being to clear out the lymphatics above the sprain thereby increasing the tissue drainage. The second or third day direct diathermy may be employed using plates of different sizes to localize the heat in the

torn ligaments, while gentle frictions are begun directly over them. Passive and active motions are used to an increasing degree, applied in such a way as not to bring tension on the torn structures After several days, static sparks may be used around, but not over, the affected ligaments Vasomotor stimulation, by plunging the foot alternately into hot and cold water, is a useful stimulant Where there is excessive effusion into the joints the Morton wave for about twenty minutes should be given, followed by sparks In the case of the knee, a blunt U shaped electrode may be applied so as not to include the patella This procedure has often been so efficient in removing non hemorrhagic fluid from the joint that aspiration was unnecessary

Toxic Arthritis—Symptomatic relief and temporary improvement *may be secured by treatment before the focus of infection has been eliminated*, but the results are naturally greatly accelerated afterwards Where persistent search has revealed no source, long continued treatment will often completely clear up the local joint manifestation. The patients should be warned of the temporary exacerbation of the joint condition which often follows removal of infected tonsils or teeth After such removal accelerated recovery is the rule

The technic used consists in superficial heat by means of radiant light, superheated dry air or paraffin bath, direct diathermy, static Morton wave and sparks and massage, largely effleurage A hydrotherapeutic application of hot whirlpool bath followed by cold pressure douche has been used Relative rest of the joint is indicated

Arthritis Deformans—This condition has proven resistant to all types of therapy and yet under modern attack is by no means a hopeless one The accepted conception of the etiology requires that the physiotherapeutic treatment be directed both at the eliminative mechanism and the joint symptoms It has been the rule that those joints involved for a period of not over a year yield rather readily to intensive treatment The dietary regulation search for focus of infection and correction of the entire regime of the patient, must be attended to with more care than is necessary in most other conditions

General body irradiation with the air-cooled quartz light, static wave over the liver, and deep abdominal massage and exercises should be given while the local conditions are being treated The affected joints are treated by 1,500 candle power radiant light, paraffin bath or other local heat with high frequency pushed to tolerance, or diathermy If several joints of both upper limbs are involved, an autocondensation handle may be used from both d Arsonval terminals Massage—largely frictions and effleurage—or mechanical vibration are used Static sparks are useful in the early stages of joint involvement

This has the appearance of being a ' shotgun prescription but each modality is aimed at a perfectly definite indication Where it has been

faithfully followed out, the results have been almost uniformly to arrest and improve the condition

Gout—In the acute stage no measurable effect can be produced on the constitutional symptoms Locally intense radiant light paraffin or whirlpool bath relieves the local pain W J Turrell has obtained good results with diathermy but calls attention to the fact that an exacerbation of the general symptoms often follows intensive local diathermy due, he believes to reabsorption and the deposits from the involved joints A good technic for the application of diathermy is with the patient prone, his toes in saline containing one electrode the other electrode applied as a cuff above the ankle Static brush and small sparks following local heat will relieve pain and hasten absorption Positive galvanization has been used in the chronic stage Here too static sparks may be used to tolerance following the application of local heat

Infectious Arthritis—This type of arthritis as typified by gonococcal infection, has shown limitation both of the disability time and in the amount of joint destruction in a very large number of cases in one of our Marine Hospitals We used in this group, the following technic In joints very acutely tender where manipulation or the slightest pressure was unbearable very prolonged radiant light was applied to the entire circumference of the joint In bed case the 100 candle-power light on a stand was fixed some thirty inches from the patient and applied for a number of hours In the subacute stage intensive through and through direct diathermy was given cross firing the joint where possible from two different directions We used about 1 500 milliamperes for forty minutes The gonococcus is rather readily destroyed by high temperatures and it is believed that both radiant light and diathermy not only inhibit the growth but to some extent actually destroy the organism No massage or manipulation of any kind should be employed in this stage Cumberbatch mentions the fact that occasionally the galvanic current is more sedative than diathermy and we found this true in several of our cases

In the chronic stage massage consisting of frictions and effleurage and active and passive motions are used with increasing vigor There was not available a static machine in this group of cases but in others it has been used in the chronic stage in the form of sparks with considerable success The effluve is useful also in the subacute stage

Tuberculous Arthritis—This presents a somewhat different problem Applications of intensive radiant light and diathermy are here coupled with general and local irradiation by ultraviolet light Local treatment is given with gentle compression only over those affected joints which are fairly superficial The general treatment should be pushed as fast as tanning will permit, dividing the body into two segments front and back, in those who tan readily and four with those who do not After

maximum irradiation of about twenty minutes daily has been reached and continued two or three weeks, it is advisable to reduce the time to five minutes and with one minute daily increment work up to maximum and repeat

Bursitis—In the acute stage, radiant light and heat, through and through diathermy or surface high frequency are followed by static effluve In the subacute and chronic stage, static sparks, Morton wave and frictional massage are added Passive exercise of neighboring joints should be used from the start Active movements should be instituted early in the subacute stage and increased to full range as soon as decreasing pain permits Bursa existing a dense shadow by X ray have returned to normal after several weeks of treatment.

Combined Conditions—It is quite usual for both toxic and traumatic inflammation in the main joint regions to find more than one tissue involved in the process It may be the joint and bursæ only, or nearby nerve trunks and muscles may also be affected The diagnosis is usually made according to the structure which is most involved in the inflammatory process. The treatment is somewhat similar and its minor variations are determined by the main indications as given for these conditions, separately considered

DISEASES OF THE CARDIOVASCULAR SYSTEM

Hypertension and Arteriosclerosis—In simple hypertension autocondensation has proved of value To obtain good results the use of a well-constructed autocondensation mattress and the larger type of better made machine are essential The small, folding electrodes and light portable type of apparatus will not give satisfactory results A careful record should be kept before and after each treatment It has been the rule to secure a temporary reduction of systolic pressure of between 8 and 20 mm Hg between the beginning and end of a single twelve-minute treatment[1] The pressure reading will generally return to within 2 to 5 mm Hg of the former reading before the next treatment leaving a small permanent gain each time Both the reduction secured during the treatment and the amount of net gain retained between treatments steadily lessens as the normal systolic pressure for that individual is approached It should be stated that Turrell and one or two others do not believe that a permanent gain can be secured by means of autocondensation The average degree of improvement stated however, is the result of personal experience and that of many others in this field

The initial cause of the hypertension remaining there is a constant

[1] A systolic range of from 8 to 20 millimeters of mercury is quite usual in hypertensives without any treatment whatever or under varied forms of treatment —EDITOR.

tendency for the patient without treatment to return to his former condition Generally speaking, the hypertension may be kept down, after it has once been reduced to approximately normal by periodic treatments, varying from one week to two months apart in different patients

The patient is placed in a reclining position on the autocondensation mattress, attached to one pole of the d Arsonval current A steel cylinder or non vacuum autocondensation rod is held lightly, but firmly, in both hands The hands should be held free from the body by placing a small pillow beneath them Better results follow the application of the current for twelve to thirty minutes at 00 to 800 milliamperes, than in stronger amounts or for a shorter length of time

Another quite satisfactory technic is a combination of body-cabinet radiant light baths for ten to twenty minutes followed by a warm shower, tub or mild Scotch douche Body exposure in the reclining position to superheated dry air for one half to one hour, followed by several hours of rest in bed, after the technic of Byron Sprague Price of New York has also secured good results The application of surface high frequency along the spine is recommended by some but its effects are not as efficient as those obtained with autocondensation or hydrotherapy Again the reader is reminded that all types of static particularly brush and charge are contra indicated in any marked degree of hypertension

Arteriosclerosis with its associated hypertension is a much more difficult problem For the adequate supply of nutrition to reach the tissues through thickened blood vessel walls a certain amount of hypertension is essential If this tension is lowered too quickly or to too great a degree dizziness, weakness and other unpleasant symptoms occur While it is true that, with real sclerosis hypertension does not come down as quickly or as far as in the simple type I have several times seen it reduced below this level of safety

Autocondensation therefore should be used with extreme care in an attempt to lower the blood pressure somewhat at least to below the point of immediate danger from cerebral hemorrhage Keep careful track of the patient s general feeling and condition as well as the pressure findings, making no attempt to reach the degree of pressure considered normal for the patient s age Occasional cases will be found in which the pressure cannot be lowered, and some cases have been reported in which there was an apparent rise following treatment Light general massage consisting of effleurage and petrissage and mild general exercises are indicated for their general effect upon metabolism. Sedative baths simple aerated or medicated may also be employed

Hypotension—Some phases in the treatment of this condition have been discussed in its common association with neurasthenia Static charge, spinal vibration general massage and graded exercises increasing in vigor, have a distinct effect in raising systolic blood pressure The tonic

contrast, Scotch douche, especially to the spine, increasing the variation of temperature, will often accomplish the desired result

Phlebitis—This is one of those conditions in which the intense pain is difficult to allay with ordinary medical and surgical procedures Not being ambulatory, there are few cases reported in physiotherapeutic literature As before mentioned, this is one of the few conditions in which diathermy has been named as a contra indication by most writers The results attained by its use, however, in a number of recent cases, has led me to doubt whether there is any real contra indication to the employment of this modality Radiant light from an ordinary hand lamp, with or without the stand, applied to tolerance directly over the affected veins, is distinctly analgesic We have followed this application by diathermy given by the double cuff or plate, or the zone method, used above and below the affected part The superficial or edge effect of diathermy so applied is of distinct value In inflammation of the internal saphenous vein the commonest site of phlebitis, a flexible, metal plate electrode is placed on the inside of the thigh, the other on the inside of the ankle, and about 500 to 1,000 milliamperes of current are given, for from twenty to forty minutes The relief from pain in these cases has been very marked, and it is difficult to see how there is any danger of producing embolism No manipulations of any kind should be employed in any stage of this disease, preceding organization

Endarteritis Obliterans—It is probable that we have at hand no means of curing this condition It may, however, be retarded and arrested, for a time, by the use of physical measures Any degree of arteriole and capillary dilatation obtainable will allow an increased amount of serum, rich in nutriment, to pass through into the tissues Such superficial dilatation can be secured by the whirlpool bath, paraffin bath, etc Dilatation of the deeper capillaries is certainly obtainable by direct diathermy As a rule however, in these conditions, some modification of zone diathermy technic must be used Occasionally diathermy increases the pain It is not safe or advisable to give more than 1,000 milliamperes The so-called vasomotor gymnastics, obtained by the use of contrast baths, or the contrast Scotch douche, are also beneficial

Anemia and Chlorosis—It has been stated before that the effects of physical agents, especially light, on the blood count and hemoglobin percentage have varied in the hands of different investigators The predominating opinion is that improvement follows where heliotherapy or quartz light and general tonic treatment are employed

Heliotherapy, where the climate permits, is administered by direct exposure of the entire body to the unfiltered rays of the sun, beginning with fifteen to thirty minutes and progressing to from one to three hours, as tanning permits The average daily increase in time is five to ten minutes

Ultraviolet light, when available, is a more certain aid. The anterior and posterior portions of the body may be exposed on alternate days or in those who tan poorly the chest, back and the anterior and posterior surface of the extremities may be irradiated in turn. The air-cooled lamp is used. The initial distance is thirty inches with the mercury tungsten and eighteen inches with the all mercury burner. The average time is a minute and a half, with ten seconds daily increment with the former type of burner, and three minutes with a fifteen second increase when using the latter type. A maximum time of thirty minutes is sufficient maintained one week. It is better then to drop back to 25 per cent of the dose and repeat.

The tonic hydrotherapy with fan douche, general massage and easy graded exercises are available adjuncts to phototherapy in the treatment of this condition.

Organic Valvular Lesions of the Heart.—In the section on the physiology and therapeutic application of exercise the behavior of the normal heart under exertion and the use of exercise in training the normal heart to maximum efficiency were discussed. The work of Halsey, Barringer and Wilson, of New York, on the exercise tolerance of children with organic heart disease has done much to allay the fear of its employment in these conditions and still further it points to exercise as perhaps our most potent therapeutic agent in the treatment of these conditions. It is the consensus of opinion of these writers and also of others that heart failure in organic disease is practically never due to physical exertion but to reinfection. Their combined work covers several hundred cases subjected to graded exercise and there has been improvement in nearly every case.

The heart working against organic disadvantage compares well with the normal heart in its tolerance to exercise, unless its reserve power is low. Several types of exercise test and regime were employed. (1) Walk one hundred yards on level ground in two minutes. (2) Climb stairs with ten foot rise in twenty seconds. A simple test available anywhere consisted in swinging two iron dumb-bells from overhead to between the feet and returning at the rhythm of thirty times a minute. The dumb-bells used weighed from two to ten pounds each and this exercise was repeated ten to forty times starting with the lighter weight and the lesser number of times and gradually increasing the severity of the exercise.

The points to be noted in judging the effect of exercise are:

1. The appearance of the face, as regards flushing and signs of fatigue and strain.
2. The respiration.
3. The time required for the pulse to return to normal.
4. The systolic blood pressure rise.

Functional Cardiac Disturbances—In our Army Hospital at Lakewood New Jersey, and at Walter Reed Hospital in Washington, a very large group of cases of this type were treated They were variously classified as tachycardia or effort syndrome and were similar to those classified 'D A H of the British Army The work at Walter Reed under the direction of the chief aide Mary McMillan, and her assistants, has been reported in detail by Lt Col Burt W Carr, now Supervisor of Physiotherapy for the U S Veterans Bureau These patients were treated with systematic graded exercises largely of the rhythmic type

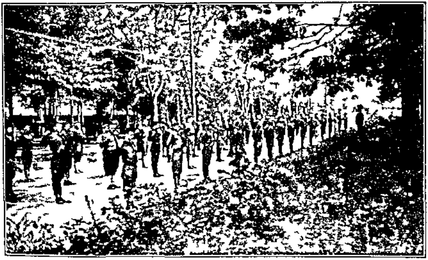

FIG 6—CARDIOVASCULAR CLASS IN ARMY HOSPITAL.

checked up with constant observation and blood pressure and pulse findings The list of exercises was divided roughly into five groups

1 Passive and assistive exercise generally in the horizontal position
2 Active slow rhythmic movements prone or standing
3 Active movements with coordination
4 Active movements including both speed and coordination
5 Walking running and indoor baseball and other light games

The patients were thoroughly examined and assigned to an appropriate grade of work In case of any doubt they were placed in the next lower grade Those admitted to Grade 1 were as a rule under nervous tension with high pulse rate and very apparent effort syndrome The exercises were given in slow rhythm associated with respiratory movements and given in a low and monotonous tone of voice Frequent rest periods with complete relaxation were taken Careful examination was made upon

Barringer states that a rise of 20 mm Hg, without other indications of strain, is a favorable sign and emphasizes the fact that no exercise other than sitting up should be attempted for a week or ten days after an acute attack has ceased and the temperature has become normal Halsey concludes that graded exercise may be given to children with organic heart disease, improving the action of the heart

In a large group of cases, May G Wilson made some interesting observations on the exercise tolerance of children with a variety of cardiac defects, comparing them with the tolerance of the normal children The results of her tests were as follows

Tolerance to exercise is roughly grouped as good, fair or poor

Twelve with congenital malformations—all good

Thirty six mitral insufficiency—twenty three normal, thirteen fair

Twenty mitral stenosis—twelve normal, eight fair

Two with aortic regurgitation and mitral stenosis—both normal

Six with chronic valvular insufficiency—poor, improving steadily with exercise

Nineteen with apical systolic murmurs—eighteen normal, one poor

One hundred and sixteen organic cases under treatment—three died, one with tuberculous complications and two from acute myocarditis following tonsilitis

Other forms of simple graded exercises would undoubtedly attain similar results These are the types of cases in which it has been quite the rule to proscribe all exercise The value of exercise in organic heart disease, especially in the young should no longer be in doubt Certainly exercise should seldom be proscribed in functional cases

Myocarditis —Graded exercises light in type and brief in duration, such as those described for valvular lesions, are indicated in this condition as well, with a careful checking up of the associated physical findings This is one of the few cardiac conditions in which the results of the application of diathermy have been distinctly beneficial Flexible composition plates, about five by seven inches are used anteroposteriorly It is essential to have a steady current which must be applied very gradually From five to seven minutes should be used in raising the current to maximum of 500 to 600 milliamperes which is maintained for twenty minutes using in addition four minutes in which slowly to reduce the strength of the current Relative rest should be insisted upon for at least two hours after the treatment Its effect upon the coronary circulation brings improved nutrition of the heart fibers

Intermittent Claudication —Grunbaum, of Vienna reports success in eight cases of this condition treated by a technic of direct diathermy similar to that just described extending over a period of four to eight weeks These cases were mild in type and his results were uniformly good

functional cardiac disorder" He was dyspneic nervous and his tachycardia was greatly exaggerated on the slightest effort

July 16—pulse sitting 116 standing 150
July 28—pulse sitting 72 standing 75

IMPROVEMENT STATISTICS FOR WEEK

Grade 3	Average Pulse Rate	
	Sitting	Standing
July 8		
Before exercise	85½	98
After exercise	84	92
August 5		
Before exercise	86	92
After exercise		86½

During the summer he was able to take part in indoor baseball and other games

Shott Nauheim Exercises—This is a group of slow resistive exercises given with the object of strengthening the cardiac muscle lowering the pulse rate and improving the entire cardiovascular adjustment The exercises are divided roughly into arm trunk and leg movements given resisted by the operator, the patient standing The operator resists shoulder abduction and adduction flexion and extension abduction and adduction in the horizontal plane and flexion and extension of the elbow He then resists trunk bending to the right and left and flexion and extension of the hip knee bent and knee extended Considerable effort is required in the maintainance of the erect position In addition much more enters into the resistive leg movements than the effort involved in their simple execution because they require in many cases balancing on the other leg during the entire time of the slowly executed movement Resistive exercises in which class all of these fall have been grouped as the most severe of the four types classified As illustrated in numerous texts these disadvantages are at once apparent and the writer believes that this type of exercise will be entirely superseded by the newer methods just outlined It is easy to understand that even a single one of these leg resistive balancing movements might be too strenuous for a large proportion of the type of cases we had in the army Contrast the severity of a single one of these movements with that of an entire group of bilateral slow, rhythmic joint flexions and extensions done as passive assistive or even active exercises with the patient lying supine Nearly every single leg exercise of the Shott Nauheim group would be strenuous enough to fall into Grade 2 of our army classification

the least sign of distress on the part of the patient The lessening of the accelerated pulse rate, in practically this entire group was remarkable after exercise and was found to be still lower an hour later The exercises included in Grade 2, which was one of the largest groups during most of the time, were as follows Patients supine on mats

1 Arms extended sideward Slowly supinated during inspiration pronated during expiration, repeated twelve times

2 Arms at sides Inhale and abduct thighs Exhale and adduct thighs Repeat

3 Hands loosely on chest Inhale and extend arms at sides Reverse and repeat

4 Inhale and draw up knees Reverse and repeat Slowly assume standing position

5 Hands loosely clenched, on chest Inhale, bringing arms to sides Reverse and repeat

6 Inhale, raising thigh with knee bent Exhale, extending leg in hale lowering foot to floor about twelve inches in front of the other Exhale, bringing foot back even with the other Repeat

7 Hands on hips Inhale, bending body forward Reverse and repeat Head up all the time

Statistics compiled by Lt Col Carr from Grades 2 and 3 showing the average improvement during a single week are significant

IMPROVEMENT STATISTICS FOR WEEK

Grade	Average Pulse Rate	
	Sitting	Standing
July 28		
Before exercise	8[illegible]⅔	10[illegible]⅔
After exercise	80	9[illegible]
August 5		
Before exercise	81⅔	91
After exercise	79	84⅓

It is interesting to note that before exercise on July 28 the pulse rate was increased twelve beats by standing and after exercise thirteen beats, and on August 5 the increase was but nine and one third and five and two thirds.

This decrease in pulse rate following exercise was practically constant A few organic cases with normal heart rates were included in the averages which makes the gain in the functional cases all the more striking One case is of especial interest Lieutenant Colonel B , Diagnosis

Gastric and Duodenal Ulcers—Temporary relief from pain may be obtained through the application of radiant light Some writers believe that the body raying with ultraviolet light is an aid in the healing process There are certainly no contra indications to its use The application of diathermy, enthusiastically recommended by some, impresses the writer as containing an element of danger of hemorrhage which it is difficult to guard against, and it should be applied if at all, with extreme caution With improved technic it may be possible in the near future to reach ulcers in the lower part of the colon by the direct application of ultraviolet light

Visceroptosis—This condition when associated with general neurasthenia lordosis or chronic constipation should receive treatment for the combined conditions The treatment of the visceroptosis consists largely of abdominal massage and the following exercises

1 Hands palms down under hips Flex both knees to chest, extend knees slowly and repeat

2 Raise both legs to vertical, knees extended lower slowly and repeat

3 With arms extended overhead feet fixed under any convenient object whip arms forward and sit up and return Repeat

Progression in the severity of this last exercise is attained by performing the exercises next with the arms at the sides then behind the neck and last with arms overhead but lifted with the body, instead of actively assisting the movement as was done in the first place General progression should proceed from an initial start of three or four repetitions of each movement to twelve or sixteen of each The abdominal massage consists of circular deep kneading covering the entire surface of the abdomen

Chronic Constipation—To obtain a satisfactory result in the treatment of this usually resistant condition every mode of attack at our command must be followed The diet habit time factor and occasionally medicinal aid must all be employed with physiotherapy In cases where the underlying cause is adhesions the physiotherapeutic treatment to be outlined cannot be expected to attain a cure However, the development and toughening of the abdominal musculature and improvement in the general condition which usually follows its application, is a distinct asset if operation should be found necessary These measures would be distinctly contra indicated when the underlying cause is inflammatory in nature although in this case a course of direct abdominal diathermy in place of the treatment outlined, might relieve the condition and make operation unnecessary The treatment of simple chronic constipation consists in the use of a combination of exercises massage and electrotherapy

DISEASES OF THE GASTRO INTESTINAL TRACT

Pyorrhea and Apical Abscess—The perfection of a variety of curved quartz applicators now permits of the direct application of ultraviolet light from the water-cooled lamp with compression upon all parts of the gums Spongy, bleeding gums, with pyorrhea, yield very quickly, as a rule, to ultraviolet exposure A narrow tipped, curved applicator is applied to the dental margin, with firm compression The initial time is from forty to eighty seconds with a ten or fifteen second daily increment The site of an apical abscess, located by the X ray, may be treated anteriorly and posteriorly in the same way, and subsequent X rays have clearly demonstrated that, in many cases, the active condition has been eliminated From six to twelve treatments are usually required

Gastritis—Bordier and Setzu both found that diathermy, applied to the stomach has a constant and uniform stimulating action on both the *motor and secretory gastric functions* *In both chronic and acute gastritis*, the relief of pain is greater than that which might be secured by the application of any external form of heat A careful diagnosis, to rule out malignancy or ulcer, is essential, since diathermy is contra indicated in both these conditions Treatment should be given by means of fairly large flexible metal plates, perhaps even by nine inches, applied anteroposteriorly over the gastric area, using 1,000 to 1,800 milliamperes of current for twenty minutes

Cholecystitis—There have been many reports upon the favorable effect of diathermy in thinning inspissated bile During the passage of a small calculus, the relaxing and analgesic effect of diathermy is of distinct value in aiding the passage of the calculus into the intestine It is not believed that diathermy can have any effect in causing the absorption of calculi once they are formed Diathermy should be applied anteroposteriorly by the direct method, over the gall bladder area As is the case in all abdominal diathermy, fairly strong currents must be used, because of the low resistance of the tissues, if any great degree of internal heat is to be produced Functional hypo activity of the liver may be greatly stimulated by the twenty minute application anteriorally of the static wave over the entire hepatic region

Appendicitis—In the initial inflammatory stage, before the formation of pus, direct diathermy has apparently aborted many cases The most careful checking up of the blood count with the pulse and temperature is essential, so that delay in the application of surgical relief will not occur should pus be formed In the preliminary stage mentioned, twenty minutes application of the 1,500 candle power radiant light, followed by direct diathermy, *1,500 to 2,000 milliamperes for the same length of* time, is advised

is advisable Either the non vacuum or vacuum glass electrode may be used Four to six hundred milliamperes of current should be given for from fifteen to twenty minutes

Hemorrhoids and Anal Fissures —The technic perfected by William I Clark, of Philadelphia in the treatment of these conditions by desiccation has been extremely successful Desiccation has many points in its favor over the use of the cautery The monopolar Oudin current is used This current is applied by means of a needle attached to an insulated handle and connected by an insulated wire to the high frequency apparatus Small hemorrhoids are treated by fulguration with a short spark jump through the air Contact is used on medium sized and direct insertion in the larger veins Local novocain anesthesia is used intermuscularly In treating external hemorrhoids Clark desiccates a line across the hemorrhoid similar to the primary scalpel incision in the usual technic The needle is then inserted into the clot and the vein destroyed The hemorrhoid is then incised without hemorrhage and the clot curetted out

Internal Hemorrhoids —Occasionally a general anesthesia is employed but usually thorough local anesthetization is sufficient After the sphincter is sufficiently dilated each hemorrhoid is grasped by the forceps and clamped at its base in the direction of the muscle fibers the needle is inserted and the growth destroyed

Fissures —Fissures should be thoroughly desiccated followed by curetting the base is then desiccated again The infected membrane is thus thoroughly destroyed and the entire tract sterilized Reinfection has not occurred in Clark's cases The advantage of this method of treatment is given by Clark as follows There is slight postoperative discomfort danger of stenosis avoided because of the small amount of cicatrix formed as the trauma of the tissues is very slight Embolism is avoided because the dilated veins are completely destroyed and no chance is given for clotting Secondary hemorrhage does not occur because the vessels are sealed for a short distance below the blades of the clamp

DISEASES OF THE RESPIRATORY SYSTEM

Coryza —Innumerable methods of attack have been used upon this common condition In the conjunctive stage the combined use of several physical agencies has been pretty successful in treating this affection We cover the eyes with a folded towel and expose the face to 1,500 candle-power radiant light as closely as the patient will tolerate usually twelve to sixteen inches for fifteen minutes This is followed by the use of the Oudin high frequency current in each naris by means of the nasal vacuum or non vacuum electrode The electrode is gently inserted and carried

Exercises.—The four exercises just outlined for visceroptosis are useful. Their object is alternately to increase and decrease intra-abdominal pressure, thereby stimulating peristalsis. The following abdominal and trunk exercises should also be used in connection with the foregoing group.

1. Stride, stand. arms horizontal, or hands on hips. Trunk to the right bend, straighten, to the left bend, straighten, and repeat.
2. Trunk to the right turn, return, to the left, turn, return and repeat.
3. Trunk forward lower, raise, gently backward, bend, straighten, and repeat.

Massage.—This consists of deep pressure movements following the course of the large intestine. The patient should lie supine, knees flexed and abdominal wall completely relaxed. The operator places one hand above the other, finger tips on the right lower quadrant. A series of four or five deep circular movements with firm gentle pressure are given over the cecum. The hands are lifted and replaced two or three inches higher on the ascending colon. This procedure is repeated throughout the entire course of the large intestine. With the hands in the same position, using the entire palmar surface, deep, slow stroking is done also along the full course of the colon. Walking, golf, volley ball and similar general exercises are indicated.

Electrotherapy.—The musculature of the abdominal wall and, to some extent, that in the walls of the intestines may be stimulated to increased action by the contractile electrical currents. The surging sinusoidal or wave galvanic currents, twenty to thirty waves to the minute for twelve minutes, are best for this purpose. One electrode, about six by nine inches, is placed over the lower dorsal and lumbar spine, the other on the abdominal wall. A slow, deep, current wave with voltage to tolerance and a distinct rest period between contractions is indicated. Uncomplicated cases of many years' duration have been made practically normal by this combined treatment. Some writers employ the static wave over the liver and also on the abdominal wall. Attention should be directed to the associated conditions so often present. Among these are neurasthenia, visceroptosis, faulty posture and the general effects of sedentary living.

Sigmoid Impaction.—This condition, when due to atonic conditions of the musculature of the lower bowel, may be treated along the lines just given and, in addition, internal rectal application of one electrode, the other being placed on the lower abdominal wall. Either the sinusoidal or wave galvanic may be employed. The lower bowel should be thoroughly cleaned out before treatments. In cases due to sphincteric spasm treatment by diathermy, using one rectal and one abdominal surface electrode,

is advisable Either the non vacuum or vacuum glass electrode may be used Four to six hundred milliamperes of current should be given for from fifteen to twenty minutes

Hemorrhoids and Anal Fissures—The technic perfected by William L Clark of Philadelphia, in the treatment of these conditions by desiccation has been extremely successful Desiccation has many points in its favor over the use of the cautery The monopolar Oudin current is used This current is applied by means of a needle attached to an insulated handle and connected by an insulated wire to the high frequency apparatus Small hemorrhoids are treated by fulguration with a short spark jump through the air Contact is used on medium sized and direct insertion in the larger veins Local novocain anesthesia is used intermuscularly In treating external hemorrhoids Clark desiccates a line across the hemorrhoid similar to the primary scalpel incision in the usual technic The needle is then inserted into the clot and the vein destroyed The hemorrhoid is then incised without hemorrhage and the clot curetted out

Internal Hemorrhoids—Occasionally a general anesthesia is employed but usually thorough local anesthetization is sufficient After the sphincter is sufficiently dilated each hemorrhoid is grasped by the forceps and clamped at its base in the direction of the muscle fibers the needle is inserted and the growth destroyed

Fissures—Fissures should be thoroughly desiccated followed by curetting the base is then desiccated again The infected membrane is thus thoroughly destroyed and the entire tract sterilized Reinfection has not occurred in Clark's cases The advantage of this method of treatment is given by Clark as follows There is slight postoperative discomfort danger of stenosis avoided because of the small amount of cicatrix formed, as the trauma of the tissues is very slight Embolism is avoided because the dilated veins are completely destroyed and no chance is given for clotting Secondary hemorrhage does not occur because the vessels are sealed for a short distance below the blades of the clamp

DISEASES OF THE RESPIRATORY SYSTEM

Coryza—Innumerable methods of attack have been used upon this common condition In the congestive stage the combined use of several physical agencies has been pretty successful in treating this affection We cover the eyes with a folded towel and expose the face to 1 500 candle-power radiant light as closely as the patient will tolerate usually twelve to sixteen inches for fifteen minutes This is followed by the use of the Oudin high frequency current in each naris by means of the nasal vacuum or non vacuum electrode The electrode is gently inserted and carried

straight back as far as it will penetrate easily, before the current is turned on. The first rheostat and first spark gap usually give sufficient current. The electrode is pressed gently against the different parts of the walls of the nasal passage. The current should then be turned off, the electrode withdrawn and inserted into the other side. From five to eight minutes application of the current to each nostril is usually sufficient to dry off and shrink the membranes considerably.

The quartz light is then applied from the water-cooled lamp through the nasal applicator inserted as deeply as possible, for a minute and a half, after which it is slowly withdrawn, during the next half minute. In throats open enough to allow for the procedure, the pharyngeal applicator may then be applied through the mouth to the nasopharynx, which is irradiated for two to three minutes. In the chronic stage of this condition, the treatment is much less efficient but even then gives symptomatic relief. If the treatment has been instituted promptly in the acute stage it is usual for the disease to yield very quickly.

Tonsillitis.—Three common types of tonsillar involvement in children have been described, associated usually with hypertrophy: the acutely inflamed, those with subacute and chronic inflammation and the simple enlarged tonsil. The first type should be removed surgically when possible. The second type treated by combined X ray and the application of ultraviolet light, and the third by X ray or by surgical removal. In subacute inflammation the X ray is applied by the Witherbee technic on alternate weeks. In applying the ultraviolet light, Pacini advises frequent short exposures of not over thirty seconds each, with the use of the special tonsillar applicator. This is a conical steel cylinder, with a quartz compression applicator fitted to its tip. He emphasizes the point that prolonged exposure tends to coagulate the protein of the mucosa which interferes with surface drainage. The spraying of the tonsils with a dilute solution of peroxid of hydrogen is sometimes advisable.

In surface infections of the tonsil and infected crypts, Donnelly advises the use of a localizing cylinder, beveled at the end to enclose the tonsil which is exposed for from three to five minutes with the water cooled lamp. Where for any reason ordinary tonsillectomy might be contra indicated, as in hemophilia or in patients unable to take a general anesthetic, W. J. Harrison, of England, uses surgical diathermy. The surface of the tonsil is painted with iodin and it is then destroyed by electrocoagulation, using 300 to 500 milliamperes of current. William D. McFee of Haverhill has developed a technic for the removal of tonsils by fulguration with the monopolar high frequency current. A special tonsil electrode is used, of wire imbedded in glass, terminating at the center of a hooded, bell shaped end. This method requires from three to six applications, the slough coming away without hemorrhage, and it is very satisfactory when ordinary surgical enucleation is impossible.

Diphtheria Carriers—Donnelly reports forty cases of diphtheria carriers to whom ultraviolet light was applied to the tonsils and nasopharynx by the use of the cylindrical localizer and water cooled lamp The first exposures were three to five minutes and if succeeding cultures were not negative repeated doses of from four to six minutes each were given Fifty per cent of these cases were negative after the first exposure and never more than three exposures were required Additional cultures should be taken several days later

In our series of five cases the ultraviolet light was applied from water cooled lamp to the tonsils and throat by the tonsillar applicator for three minutes and to the posterior nares by the quartz nasal applicator for two minutes, including the slow gradual withdrawal of the applicator during the last half minute Cultures were not taken in this group until after three exposures when four were found negative and one doubtful which also became negative after the fourth exposure Pacini follows the same technic with a shorter exposure less than a minute and adds the curved rod applicator, turned upward beyond the soft palate into the nasopharynx This last procedure is important in completing the irradiation of the entire surface most commonly infected The middle ear and sinuses occasionally involved cannot be reached directly So eminently satisfactory has been this treatment that it suggests similar results in carriers of the organisms of meningitis pneumonia and influenza, both in the recuperative stage and as a preventive for those who have been definitely exposed There can be no question that ultraviolet light is perhaps the least dangerous and most effective surface bactericide at our command

Tuberculous Laryngitis—Blegrad reports fifty two cases treated by body exposure to the carbon arc light The initial exposure was fifteen minutes, increasing gradually to one hour in about a week s time On deep-seated local lesions he used the galvanocautery The laryngeal symptoms were greatly improved in practically every case, although the associated pulmonary condition prevented complete cure in quite a large proportion of them

A comprehensive technic includes the local application of ultraviolet light from the water-cooled lamp through the laryngeal applicator for from one to two minutes with slow steady increase in exposure time coupled with cross-firing the larynx by means of compression with the large surface applicator and body exposure following the technic already outlined

Gas Laryngitis—We have had many cases of gas laryngitis among the ex-service men A combination of surface high frequency and the internal and external application of quartz light, as just described, has brought good results in most cases

Simple catarrhal laryngitis may be treated in the same way, adding intensive radiant light externally for twenty minutes

Sinusitis—There is no question that the sinuses connected with the respiratory tract can be penetrated by radiant light and, to some extent, by ultraviolet light, when properly applied The effect is that of thinning and, to some extent, sterilizing the exudate, thus accelerating drainage Local, intensive, high candle-power radiant light for twenty to thirty minutes is applied directly over the affected area as close to the patient as is tolerable Ultraviolet light with compression from the water-cooled lamp is then used for one or two minutes The patient should be forewarned of the sunburn on the face which will follow this application Marked relief of pain is usually the immediate result of the treatment Ultraviolet light should be applied, where possible, through the nose, in addition to the surface application

Bronchitis—The favorable effect of the common external counter irritants is well known The use of hot, heavy gummy substances smeared on the skin is still in vogue, in spite of their obvious disadvantages The effects of these can be obtained much more efficiently by the use of high candle power radiant light

In certain types of bronchitis, especially those associated with a tendency to asthma and simple croup, antispasmodics are indicated Diathermy will relieve this condition by the relaxing effect of the intense deep-seated heat produced The sedative effect on the mucosa of the larger and smaller bronchi is more quickly secured than by the use of drugs In cases where the expectoration is too profuse, diathermy should be used sparingly if at all

Radiant light, 1,000 to 1,500 candle-power at fifteen inches, is applied, thirty minutes to the anterior and ten minutes each to the lateral and posterior surfaces of the chest This is followed by direct diathermy with flexible metal plates large enough to cover the entire upper chest The patient may lie on the posterior plate The anterior electrode may be held gently on the chest by the patient, but preferably by a light sandbag or with adhesive plaster Use 1,000 to 1,500 milliamperes of current, taking double the usual time to reach maximum and to reduce the current

Bronchopneumonia—The effect of the application of radiant light is not as great in this condition as in inflammation of larger bronchi, while that of diathermy is still more striking Radiant light, however, should be used where possible, applied to the anterior chest wall for twenty to thirty minutes Diathermy is given by the technic just described

Lobar Pneumonia—The group of cases in my consulting service, in the United States Marine Hospital No 21, New York, is now large enough to justify certain definite conclusions as to the effect of diathermy in this condition This disease varies so greatly in its mortality in different seasonal epidemics and in the different types, that all conclusions as to the efficacy of any given treatment must be most guarded In the

literature, a few scattered cases of pneumonia treated by diathermy are recorded. The lack of laboratory reports and daily physical findings render difficult any judgment upon the efficiency of the methods used. The permission and assistance of the Medical Officer in Charge and the co-operation of the Ward Surgeons and Laboratory Staff made this study possible. The only function of the department of physiotherapy was to give the treatment. A complete record of pulse, temperature and respiration together with daily chest findings was kept of every case by the Ward Surgeons, Dr. Trimmer and Dr. Boland, under the direction of Major Pryon and Major Pidlon, Chiefs of the Medical Service. The laboratory findings were made by the chief of that service, Dr. Taylor, and a number of chest plates of particularly interesting cases were secured. Treatments were given by the head physiotherapy aides, Miss Cargill and Miss Randall.

The apparatus used was a portable type of high frequency machine capable of delivering up to 2,500 milliamperes of current. This and similar apparatus may be conveniently carried to the different wards of a hospital or to private homes and used wherever there is an alternating current. The technic was as follows: The patient was gently turned on his side and the flexible metal plate (about five by seven inches) covered with hot shaving soap lather were placed directly over the affected lobes anteriorly and posteriorly. The patient was then returned to his former position, lying directly upon the posterior electrode, the bedding being protected by a heavy folded towel. The anterior plate was held gently against the chest wall by the aide or nurse. In the first eighteen or nineteen cases the maximum current of 2,000 milliamperes was used. The current was turned on very slowly, from four to five minutes being used to reach maximum and a further two or three in cutting it down after twenty minutes at maximum. In the second group of cases at present under treatment, the time has often been increased to thirty minutes and the maximum current reduced to 1,200 or 1,500 milliamperes with even better results.

Dr. Wm. T. Boland, who was in immediate charge of practically every case, sums up the results of this work up to February 15, 1923 from the standpoint of the internist as follows: "The 1922-1923 group of cases, largely Types I, II and III, did not respond quite as well as the first group which were mostly of Type IV. With a single exception there was a slight fall in blood pressure with a fall in pulse rate of from five to ten points following the treatments. The respiration rate was not greatly lessened but breathing was much less labored. Free perspiration was induced. Following the diathermy treatment each patient was able to sleep from one half to three hours in a quiet, natural manner and the pains in the chest were lessened following each treatment in every case except one.

The results obtained in treating lobar pneumonia with diathermy indicated that it might have an influence in hastening recovery, particularly in shortening the period of resolution There is some evidence to indicate that pneumonia may be aborted by the early and intensive use of diathermy This result has apparently been the case in a number of instances and yet it is extremely difficult to prove one way or the other It seems logical, however, to employ it at the earliest possible moment after a diagnosis or provisional diagnosis is made, because of the almost absolute certainty that it is safe The total duration of the active stage of the disease was apparently not affected in our cases, but the condition of the patient and the temperature findings were both markedly affected The temperature started down by lysis immediately following the first application of diathermy, in nearly every case A similar temperature effect was noted even in the few which had a lethal outcome

This statement can be made without fear of successful contradiction A crisis does not occur in lobar pneumonia where diathermy is used In fact, so striking is this point that in several of the scattered cases reported the diagnosis was placed in doubt because there was no crisis In our cases the laboratory reports preclude any doubt as to the accuracy of the diagnosis *Still more marked, however, are the effects obtained on the* patients' symptoms in practically every treatment, the number of which is now several hundred Cyanosis lessens or disappears, the expiratory grunt, when present, is markedly diminished, or it ceases entirely The respiration rate usually falls and the breathing is less labored The patient receives from two to four hours of distinct relief from distress during which he usually drops off to sleep

The question arises as to what actually occurs within the congested lung This question is difficult to answer but we are certain that something definite occurs which relieves, at least temporarily, the overload upon the right side of the heart Lymphatic and capillary drainage are undoubtedly augmented and the intense heat produced, estimated at from twelve to twenty degrees Fahrenheit above that of the body, may mechanically melt down some of the exudate

The relief felt by the patient after the crisis is of course, out of proportion to any sudden physical change occurring within the lung itself and a somewhat similar and unexplainable relief occurs here The body, at a great expenditure of energy, reacts to the toxins with a rise of from five to seven degrees of temperature, perhaps even greater than that within the congested lung If the organic structure of heart and kidneys and sufficient pulmonary tissue remains intact and the dose of toxin is not overwhelming crisis occurs and the patient is started on the road to recovery By means of diathermy we create, without the rapid burning of the body's available energy, a more intense and sharply localized temperature We do not, of course aid directly in the formation of anti

bodies The results which have been found clinically in the application of diathermy, therefore closely parallel what might have been expected The most careful and continuous observation of these cases has at no time demonstrated that diathermy was harmful in any stage or type of the disease Further study will undoubtedly reveal the fact that this measure is more useful in certain stages of the disease than in others It may even point to the fact that at times it is contra indicated Up to the present, however, this has not occurred It has not prevented other lobes from being affected while one lobe was being treated The few occasions when this occurred came however, at a time when the diathermy treatments had been markedly reduced because of the improvement in the lobes under treatment

It is believed that the marked symptomatic relief which follows the application of diathermy is great enough to turn the scales in many severe cases Shorter treatments at three to four hour intervals during the entire critical stage would be indicated in such conditions The writer would urge a wider employment of diathermy in pneumonia It has seemed to him to be a most hopeful type of treatment and should be coupled with the serum in those types of the disease in which serum is indicated We may confidently expect that in the near future our knowledge of the results of this type of therapy will be greatly increased

Pulmonary Tuberculosis—There has recently occurred some change in our conception of the manner in which certain physical agents play their part in the treatment of this condition It has been the writer's privilege to be associated in a consulting capacity with Major Leonard Wooley Bacon Surgical Chief, in the Physiotherapeutic Department of the Government Hospital for tuberculous ex service men at New Haven for the past three years He is indebted to Major Bacon for the exposition of the theory upon which the therapeutic application of exercise and ultraviolet light to this disease is based A brief statement of these conceptions is necessary to an understanding of the treatment regime

The tubercle bacillus produces a toxin to which the body reacts and as a result of which reaction is enabled to build up a cicatricial fibrotic encapsulation of the bacilli Within this fibrous wall the bacilli undergo slow attenuation in their virulence Under conditions favorable to them they undergo development dissolve or break through the protecting capsule and again become a menace The allergenic responses of the tissues to the invasion of the tubercle bacillus is essential to its proper defense against the organism In many cases there remains for considerable periods a state of fair balance in which partly attenuated organisms are surrounded by a fair amount of protecting cicatrix the general bodily health remaining below par Such patients while showing normal temperature at rest may exhibit an overactive thyroid hyperthyroidosis recurrent colds and typical effort syndrome These are the patients who

break down readily upon the attempt to resume normal activity. To protect such a patient properly, an increasing stimulation to the formation of adequate cicatricial tissue around the tubercle is essential. This stimulus may be obtained by intentionally stirring up the dormant bacilli to increase toxin production. By rest, fresh air and adequate nutrition the body is prepared for these responses, and the bacilli are at the same time attenuated in their virulence. This is probably the immunological action of tuberculin. A similar result may be obtained by what might be called the auto-inoculation method, using the effect of exercises and ultraviolet light to attain a systemic reaction. In seeking to *bring about this result an overdose may bring disaster.* Clinically, this condition is met with in the too early return of the patient to motor activity or in excessive doses of heliotherapy or actinotherapy. Under the stimulation of an excessive dose of toxin the body attempts to reestablish its local defenses but the areas involved are increased in both size and number and the protecting structure is necessarily weaker. Bacon suggests that the effect of exercise is due to changes in the fluids and consequent osmotic pressure, leading to increased absorption of toxins in the vicinity of the tubercles, scattered throughout the spongy tissue of the lungs. Both exercise and ultraviolet light, as will be later shown, produce concomitant effects, distinctly favorable to recuperation if graded so as to invoke the optimum response. The emphasis here made is to show how their employment in the wrong stage of the disease or in excessive amounts may be extremely harmful. Therefore, these potent agencies must also be used with extreme care. In that stage of the disease where the temperature has returned practically to normal and the active symptoms have been arrested by rest, adequate diet and fresh air, carefully graded treatment by exercises and ultraviolet light is indicated.

Exercises.—After the patient's temperature has been practically normal for some two to four weeks, the exercises in Group 1 may be given. Anything more than the slightest febrile reaction demands a further period of rest before again attempting exercise. If a few weeks employment of these gentle exercises produces no untoward symptoms, the *exercises included in Group 2 may be substituted.* Unfavorable responses to this exercise dosage place the patient back at rest or in Group 1 according to the severity of the reaction. After four to twelve weeks of work with this group a patient may be advanced to Group 3, after which he is ready for discharge from the hospital or sanitarium and should be in condition slowly and gradually to resume his former occupation. These exercises may be entrusted to the well trained physiotherapy aide or physical director but must be under the constant observation of the physician, who should withdraw at once any patient showing signs of distress.

Group 1

These exercises constitute a series of *slowly performed* gentle exercises in which all strain on the chest wall and all vigorous breathing are avoided They are slowly coordinated arm and leg exercises and very gentle trunk bendings which may be performed in recumbent sitting or standing positions From two to four repetitions of each joint movement are sufficient Rest periods are very frequent during the ten to twenty minutes lesson

Group 2

The patients taking these exercises are assembled in regular class formation They are given the full number of general setting up exercises performed at a relatively slow rhythm Slowly performed marching tactics are sometimes included Three to six movements of each type are sufficient Good form in the execution of the movements is striven for but without speed or snap Rest periods are given during the half hour period

Group 3

These exercises constitute a general snappily executed, full setting up drill with the movements repeated four to eight times each with vigor and speed Walking and light games may be included in this group When the reaction to this form of exercise is favorable the patients are ready for their discharge from the hospital or sanitarium and a return to their former occupation in fine muscular condition

In our government hospitals these exercises have the further advantage of demonstrating both to the men and to the medical staff the patients fitness for leave or discharge

Ultraviolet Light—The following technic of applying ultraviolet light to patients whose condition was complicated with pulmonary tuberculosis has been in operation more than two years at the Government Tuberculosis Hospital at New Haven and the results have proved eminently satisfactory The same technic is applicable to patients suffering from uncomplicated tuberculosis Major Bacon divides the body into eight zones four on the anterior and four on the posterior aspect The first zone extends on the anterior surface from the feet to the knees the second includes the anterior thigh region and the dorsum of the hand and wrist the third the abdomen and the anterior part of the forearm the fourth the chest and neck Zones V VI VII and VIII are corresponding areas on the posterior surface of the body Irradiation with the 2 000 candle-power light for ten minutes precedes all treatments This is an essential part of the regimen

Treatment 1

With the air-cooled mercury tungsten lamp at a distance of thirty inches, Zone I is exposed for one minute

Treatment 2

Zone I is exposed for one minute, Zones I and II for an additional minute The treatments progress in this manner until all zones have been exposed, with a total time of thirty six minutes After sixteen treatments the series has been completed and the lamp is lowered two inches, then the whole anterior surface of the body is treated for two minutes The next day the posterior surface is rayed for the same length of time This procedure is repeated until the lamp has been lowered to twenty inches, after which the zone method is again resorted to, increasing two zones at a time, instead of one, to a maximum of thirty six minutes This very gradual increase has enabled our working up to maximum in nearly every case without producing increased febrile symptoms

Hydrotherapy—The late Simon Baruch, in his text on hydrotherapy, calls attention to the stimulative effect of cool and cold water applied to the skin in pulmonary cases The water is first applied at a temperature of about 90° F and given at a slightly lower temperature in each succeeding treatment as the patient becomes used to it It may be applied as a sponge bath or by means of the fan douche and should never be given at a lower temperature than 70° F A distinct gain in appetite, sleep and weight is claimed for this method of treatment It would seem to be indicated in that stage of the condition in which active exercise has been advised and should be carefully watched for the appearance of unfavorable symptoms in exactly the same way as has been advised when exercise was given

Massage—In the beginning of the quiescent period, at that stage in which restricted use of general mild exercise was advised general massage, consisting of mild petrissage and effleurage, may be employed with advantage to the patient

In a light general treatment or where the four extremities only are included, only about one-third of the time should be employed as in the average general massage treatment

In the terminal stages of the disease, no procedure brings more comfort to the patient than gentle general massage It is possible to improve local circulation impeded by pressure and immobility and to prevent or delay the appearance of bed sores

Pleuritis—The pain incident to the acute inflammation of the pleura can be relieved by local intensive radiant light and surface high frequency or direct diathermy The 1,500 candle-power lamp at a distance of fif

teen to eighteen inches for thirty minutes will produce a marked analgesic effect.

Diathermy should be applied by large flexible metal plates, so arranged as to be only four or five inches apart on the affected side of the chest In this position, beside the through and through heat a distinct edge effect is produced The current will flow in greater density through the subcutaneous tissue between the plates and heat may be produced to tolerance Use 1,000 milliamperes for thirty minutes

With simple effusion the same technic is continued to promote drainage

Empyema—This complication requires surgical drainage With drainage established and even the institution of the Carrel Dakin technic all cases do not progress favorably It was in this type of case often further complicated with osteomyelitis of the resected rib stumps that physiotherapy attained some of its most brilliant results in the many post influenza cases of this type which occurred in the Army The treatment, as given does not interfere in the slightest degree with the proper surgical procedures including the Carrel Dakin tubes

Major C M Sampson and Captain A B Hirsh treated a very large group of empyema cases at Fox Hills General Hospital later the Hoff General Hospital of the Army These were largely due to infection by the Streptococcus hemolyticus many of the sequelae of the influenza pneumonia remaining

The object of the treatment is to increase the local arterial blood supply and both the quality and quantity of the phagocytes. Radiant light used alone did not produce a marked effect When combined with direct diathermy however the results were very satisfactory The first case treated had become steadily worse after nine rib resections, and had thirteen discharging sinuses

Radiant light, from a 1 500 candle-power lamp for fifteen minutes was followed by direct diathermy applied right over the scars and discharging sinuses At first 500 milliamperes of current were used gradually working up to 2,000 milliamperes for one hour General irradiation with the air-cooled ultraviolet lamp was used, with increasing time starting at twenty four inches for two minutes This case was entirely healed in a comparatively short time

Nagelschmidt Howaschick and Saberton have all attained equally good results in the application of diathermy to empyema It is clearly indicated in all forms of pleuritis

Adhesions—Cumberbatch has had results in treating the cases with chlorin ionization The writer employed in his army cases a combination of diathermy by the technic described above and deep-breathing exercises.

The graded deep-breathing exercises should be begun early while the patient is still a bed case They promote drainage and prevent the

formation of adhesions Once formed, adhesions may be stretched and broken up by their use Slow, deep respirations of the "pectoral type are given, with prolonged rest periods. They may, with advantage, be associated with bilateral arm abductions, where possible

DISEASES AND INJURIES OF THE SKIN

The use of radium X ray and ultraviolet light in the treatment of various pathological conditions of the skin is a recent and rapidly spreading development in therapeutics The relative value of each of these measures has not been definitely determined in every instance The proper selection of the treatment cannot be standardized until the dermatologists have thoroughly tried out all of these measures in cases where their application seems to be indicated Broadly speaking, this general statement holds true These physical agents are somewhat similar in action, as would be expected from the fact that they are derived from adjoining wave-lengths of light vibration In most dermatological conditions amenable to treatment by both X ray and ultraviolet light, the X ray is usually quicker in its action but has a greater tendency to scar the skin and, except under most careful technic, has certain elements of danger not involved in the use of ultraviolet rays In general and diffused conditions, like acne of the face, where temporary exfoliation by ultraviolet light might be disadvantageous, the X ray is to be preferred In most sharply localized conditions, the absolute safety of ultraviolet light is a point highly in favor of its use

Alopecia —*The general falling out of hair in early adult life* yields, as a rule, most satisfactorily to the proper application of physiotherapy Bernstein uses the air cooled all mercury burner at twenty four inches for ten minutes, increasing five minutes per day to a maximum of thirty minutes He treats the parts every other day for three treatments and then twice a week Wise uses approximately the same technic with the treatments two weeks apart, and calls attention to the necessity of removing the scales if seborrheic eczema is present One should reduce the time by half in using the tungsten mercury air cooled burner It is better to move the patient s head or the lamp slightly, during the treatment, so that the hair shadows will not prevent the light from reaching all parts of the scalp

We have found a combined technic to be still more efficient Preceding the ultraviolet irradiation at the time, distance and daily increment mentioned, we use about eight minutes local application of the surface non vacuum high frequency scalp electrode which is made in the form of a coarse comb The ordinary small surface electrode, however, may be used instead of this special one A flexible metal electrode may be ap-

plied to the wrist of the operator or patient and a finger tip massage of the scalp which localizes the high frequency stimulation may then be given. This may be substituted for the application of the high frequency electrode directly to the scalp.

It will be noted in many of these cases that the scalp is quite tight and the local circulation thereby somewhat impeded. With the palms placed over the forehead and occiput, then on both temporal and finally on both parietal regions, it may be loosened somewhat by circular kneading, moving the whole scalp on the skull. It is quite usual for the hair to stop falling out and for the itching which generally accompanies this condition, to be entirely eradicated at the first treatment.

Treatment should be four times a week for four to twelve weeks to accomplish lasting and satisfactory results.

Alopecia Areata.—In this condition the etiology will to a large extent determine the success of the treatment. Certain types are amenable to treatment by the technic just given above.

Acne.—In severe cases of acne it is necessary to secure an exfoliation of the skin to produce a lasting result and the patient should be particularly warned in regard to this, especially in the treatment of the face. The few days of disfiguration are rendered well worth while by the results obtained in most cases. Fortunately the face responds particularly well to a thorough treatment. Certain writers, among them Clark, give an initial dose at twelve inches for ten minutes producing a sudden and sharp reaction. Bernstein uses an initial time of five minutes, distance thirty-six inches, adding five minutes and decreasing the distance six inches at each subsequent treatment to maximum of twenty minutes at twelve inches. He gives one treatment every other day until three have been given, then twice a week if further treatments are necessary.

Oliver points out the efficiency of ultraviolet light in acne vulgaris which may be given by the technic mentioned above or with compression by the surface applicator from the water-cooled light three to five minutes.

Pitcher states that the X-ray acts more quickly but with greater liability to the formation of scars and telangiectases.

Angioma.—This condition may be treated with the water-cooled lamp surface applicator with compression from twenty to forty minutes repeated every three weeks. Lewis Jones, Guilleminot and G. Betton Massey treat this condition by electrolysis. This may be done by the bipolar method with both needles in the tumor or by using a single needle and the indifferent electrode placed elsewhere. Jones's work at St. Bartholomew's Hospital in London has been very successful and he advises the earliest possible treatment of this condition because of its rapid growth in infants. The object is to coagulate the blood in the tumor and destroy the walls of the dilated vessel, obliterating the cavity while not destroying the overlying skin. The positive pole needle must be platinum and

the negative may be steel They should be insulated with hard rubber or shellac so that they may pass through the healthy skin without destroying it From twenty to forty minutes of current is used, according to the size of the growth Large growths require multiple needles In growths less than two centimeters in size, a single positive needle should be used with the negative electrode placed at a distance General anesthesia is sometimes necessary The time necessary to destroy the walls of the vessel is from three to five minutes Rarely more than two applications are necessary William L. Clark, of Philadelphia, uses desiccation with high frequency current with good results His technic is that attributed to him and described under Desiccation He states that radium, however, is a method of choice in very large growths

Burns.—First degree burns from any cause may be treated by prolonged radiation at about thirty inches by the radiant light Second and third-degree burns present a number of problems The best surgical opinion seems to be leaning toward the conception that these injuries should always be considered as infected wounds Sealing them in with some type of paraffin preparation occasionally gives brilliant results and does greatly allay the pain, but it is not always a safe procedure

Any method which will arrest the pain, dry up the exposed area, sterilize and at the same time markedly stimulate the new growth of skin cells may be considered an ideal procedure This ideal combination we have at hand in the ultraviolet light Those who have employed it speak most highly of the results they have obtained with it The air-cooled lamp should be used, with the all mercury burner, the initial distance is twenty inches and the time three minutes, with one minute increment of daily treatments With the mercury tungsten burner, the initial time is one minute and a half, with one-half minute daily increment. Between treatments, dressings of sterile, dry gauze, not thick enough to be impervious to the air, are desirable

Where skin grafting is necessary, the ultraviolet light should be early employed as an aid In fact, it is certain that the wider use of the ultraviolet light will decrease the indications for skin grafting In deeper burns, involving tendon sheaths and other subcutaneous structures, long continued use of ultraviolet light with the same technic as above given will greatly toughen and thicken the layer of new skin formed Massage, particularly friction and vibration, and radiant light will loosen adhesions and promote increased vascularity X ray and radium burns should always be treated with ultraviolet light by the same technic. I have seen, especially in X ray burns, the most astonishing results in a number of army cases where skin grafting had been thought necessary and was finally not employed.

Boils.—Wise states that no other remedy is as capable of relieving pain and skin tension as rapidly as ultraviolet light in furunculosis. Bern-

stein uses the air-cooled lamp ten to fifteen minutes at twelve inches carefully covering the surrounding tissue The greater bactericidal property of the water cooled lamp would indicate its use with firm gentle compression from the quartz surface applicator The length of the treatment may extend from five to twenty or even thirty minutes with no ill effect Surrounding areas should be carefully protected with adhesive plaster or other covering

Our own recent series covers about seventy five cases Those cases appearing for treatment before the central softening had occurred were aborted almost without exception by a single exposure to quartz light About four fifths of the total number of cases in our series is included in this group More advanced conditions should be incised and surgically cleaned Our technic consists of the application, as close as is tolerable of the 1,500 candle-power light for ten to twenty minutes followed by the water cooled ultraviolet light through a localizer or with compression if possible for five to ten minutes after which a drain is inserted according to the routine surgical procedure This technic is repeated daily after the old drain has been removed and the boil cleaned The period of sterilization and filling in with new tissue to complete healing is invariably reduced from 50 to 75 per cent by this combined technic It is an ideal illustration of the correlation of surgical and physiotherapeutic procedure

Carbuncles—These are treated by exactly the same technic and with the same indications as regards incision and drainage This condition too in the early stage is frequently aborted Both with carbuncles and boils extreme induration is often present in the surrounding tissue This stasis impedes the proper vascularity of the part and is usually one of the causes of the excessive pain common in these conditions The induration may be greatly diminished by the use of the static effluve Mechanical removal of the surrounding induration should be followed by an effort to increase the active blood supply to the part As has been repeatedly mentioned this can be done in no way so well as by diathermy We find in this condition a special use for the edge effect of heat concentration in the skin and subcutaneous tissue between two closely placed electrodes Flexible metal plates are therefore selected containing from three to six square inches prepared as usual and applied opposite each other a short distance from the infected tissue A small amount of current from 300 to 600 milliamperes is used The relief from pain is often almost immediate and the acceleration of the healing process is as a rule visibly hastened

Callosities—These conditions should be softened by prolonged soaking and by the application of the ordinary corn mixtures This may also be accomplished by sodium chlorid ionization using 2 to 4 per cent salt solution on the negative pole applied directly to the callus, giving 8 to 10 milliamperes of current for thirty to fifty minutes If not then re-

movable *en masse* the callus should be shaved or scraped to as great a degree as possible without causing bleeding. It may then again be ionized after the technic just described or treated with the large quartz surface applicator from the air or water-cooled ultraviolet lamp, using twenty to thirty minutes with firm compression. Recurrences can, as a rule, only be prevented by a proper redistribution of pressure or weight which was the original cause of the callus formation.

Eczema.—Eczema being a group of conditions rather than a single entity, results vary widely in the different types. As has been mentioned before, rather mild doses of *general ultraviolet light* have brought on a form of eczema in several arthritic cases. When ultraviolet light is employed particularly in local eczematous conditions, it should be given intensively. Large areas may be treated by means of the air-cooled light, with initial exposure of five minutes at thirty-six inches, decreasing the distance five inches and increasing the time five minutes daily to a maximum of twenty minutes at twelve inches. This is the technic of Bernstein. We have found, especially in our chronic cases with thick excoriated skin, that it is better to give a massive dose at once, trying to obtain a complete peeling of the epidermis following the initial treatment. From three to ten minutes at twelves inches with the air-cooled lamp will usually accomplish the desired result. With the formation of new skin, the itching has generally entirely disappeared. In many cases it is extremely difficult to obtain an even application of the light. Skin and mucous membrane folds must be carefully obliterated and all parts of the surface to be treated should be, as far as possible, equally distant from the burner.

Epithelioma.—The *squamous cell type of epithelioma* may at times be destroyed by intensive doses of ultraviolet light. It yields, however, so much more readily to the separate or combined application of X-ray and radium that the use of quartz light is hardly justifiable. Metastatic extension of this and other malignancies often require intensive exposures to the X-ray which border on a destructive skin dose. There seems to be no question that a regime of ultraviolet light, especially in those who tan, will protect the skin somewhat from X-ray burn. Just how far this protection extends and to what degree it will enable us to multiply the X-ray dosage, has not been worked out definitely.

In advanced epitheliomas, with sloughing and offensive discharge, the ultraviolet light is most useful in minimizing these distressing symptoms. There are many cases beyond surgical aid where intensive doses of the light will clean the field to a degree unapproached by practically any other means at our command.

Erysipelas.—A surprising amount of effect upon this condition has been attained by such a simple procedure as the application of radiant light. This measure should be applied to tolerance for several hours if

possible The use of ultraviolet light has been successfully employed by several writers The technic as given by them is practically the same initial distance thirty six inches time five minutes lowering the lamp a few inches daily to eighteen inches and increasing the time to a maximum of five to fifteen minutes daily Treatments should be given on alternate days It is difficult to see why with the surrounding area properly protected, a destructive skin dose of ultraviolet ten to fifteen inches for ten to fifteen minutes, depending upon the type of lamp used, should not at once be given

Erythema Induratum —Oliver reports a number of cases successfully treated by the water cooled ultraviolet lamp He carefully protects the healthy surrounding skin and uses compression from one to two minutes directly over the affected area

Leukoderma —Toomey secured by means of the air cooled light a complete pigmentation in some of the affected areas of the skin and he was able to obtain some degree of pigmentation in all areas treated This new pigmentation persisted for months with no appreciable fading Fortunately the results secured in the treatment of areas on the face were the most satisfactory of any part of the body In areas of the body normally covered by clothing only partial pigmentation may be secured

Lupus —In the erythematous type Clark secured good results in twelve cases of this condition using ultraviolet light with compression for thirty five minutes

Clark s group of cases of lupus vulgaris were cleared up by not more than three exposures He employed the same technic as in the erythematous type Finsen has secured good results with the use of the carbon arc lamp

Nevi —The flat type of nevi yield quite readily to intensive doses of ultraviolet light with firm compression It is necessary to secure a good burn and blistering to obtain a satisfactory result As much as 50 per cent improvement often follows a single application Clark Pernstein and Oliver employ a practically identical technic The surface quartz applicator with the water-cooled light and heavy compression is used from twenty to forty minutes repeated every three weeks as long as it is necessary Trevost treats the former type by surgical ionization with the galvanic current employing 5 milliamperes and using a technic similar to that described for the destruction of angioma

Psoriasis —The treatment of this condition gives quite varied results and the general tendency is to a recurrence Using the air-cooled quartz lamp Bernstein and others start with an initial distance of thirty-six inches which is reduced gradually to twelve and an initial time of ten minutes increased gradually to thirty With the surrounding areas protected there can be no objection to the more prolonged initial exposure used by Wise and Oliver, who employ from the start the maximum dose

of Bernstein's technic Treatments may be given every other day with the former and once a week with the latter technic

Pruritus—This chronic condition is very common and very resistant to all types of treatment As is well known, the palliative ointments to which most patients turn for relief tend, in the long run, to aggravate the condition Underlying constitutional causes must be considered and where possible removed There are many cases in which autogenous vaccines and local applications of all sorts bring no relief Radium and X ray are often useful, but are not always free from danger Ultraviolet light has definitely and rather permanently relieved a good many of these conditions Quartz surface applications with compression from the water-cooled lamp are to be preferred in those locations in which it is possible to use them Folds of skin and mucous membrane mu t be flat tened out so that the compression and irradiation will reach all portions *of the affected area in equal concentration. A destructive dose of* two to four minutes is indicated

In *pruritus senilis* Prevost has secured results by the application of static brush and high frequency effluve in conjunction with the X ray Rolfe reports very satisfactory results in thirty uncomplicated cases of *pruritus ani* of from eight months to thirty five years' standing From twelve to fifteen treatments were required by his method of zinc chlorid and iodin ionization which relieved at once the intensity of the symptoms An almost complete relief from the itching persists for one or two days immediately following the treatment, and the return is less inten e each time During the course of the treatments no local applications are used, but local cleanliness is insisted upon Rolfe employs a 2 per cent zinc chlorid solution The ordinary galvanic plates are used, except that the active circular electrode is provided with a flexible metal back which can be bent and carefully shaped to the contour of the part to be treated The patient is placed in the right Sims position with the indifferent electrode under the right buttocks In moist macerated conditions of the skin, the zinc chlorid applied by the positive pole is used for two or three treatments following which iodin is employed He uses Lugol s solution diluted with four parts of distilled water at first, later less dilute solutions may be applied The iodin is applied from the negative pole as the active electrode Cotton may be soaked in the solution and directly applied to the part with the active pad placed over it A rather long treatment, from thirty to forty minutes, is indicated, using only 2 or 3 milliamperes of current Treatments may be given daily at first, then twice a week. Rolfe rightly emphasizes the value of continued treatment at weekly intervals, for a short time after the disappearance of the symptoms

Tinea—This condition will often yield to intensive doses of ultraviolet light *Air-cooled or water cooled irradiations may* be given at three

to six inches distance for three to ten minutes repeated every third day as long as is necessary

Telangiectasis—This is best treated by the water-cooled ultraviolet light using surface application with compression. It may be given from ten to thirty minutes and repeated every ten days or two weeks, if necessary

Ulcers—Ordinary varicose ulcers will heal as a rule more rapidly under the application of ultraviolet light than by the usual routine surgical procedures An air cooled light is to be preferred to the water cooled, except where there is much infection, when the use of the latter is indicated Stowell emphasizes the value of preliminary surgical cleansing and the use of static sparks and effluve to reduce the induration of surrounding tissue when present This will greatly assist in relieving the lymphatic stasis and reinstituting the normal blood supply The leg should be kept elevated during the entire treatment and after the treatment should be bandaged firmly and evenly from the toes up while still elevated

The ultraviolet light should be applied in stimulative doses, the initial one being from four to five minutes at thirty inches, with a reduction of distance to eighteen inches and an increase in the time to a maximum of twenty minutes The treatments should be given every second or third day Wise reports prompt healing in many cases so treated and Oliver speaks of almost uniformly good results in twenty five of his cases which were healed with a good thick, new epithelium Oliver exposes the skin for about an inch around the ulcer and uses two minutes at ten inches once a week In my cases I have employed radiant light for ten minutes followed by the ultraviolet light and have used massage as an aid in the removal of the commonly associated lymphatic stasis

Ulcers of the pressure variety following the removal of casts or the ordinary decubital type are treated by stimulating massage of the surrounding tissues the removal of lymphatic stasis by static or massage and by the direct application of radiant light and ultraviolet light with a similar technic to that just given.

DISEASES OF THE GENITO URINARY SYSTEM

Amenorrhea—Cases where operative procedures are not indicated may be treated by physiotherapy

This condition when associated with neurasthenia and low blood pressure is amenable to treatment by static charge from the negative pole Where anemia is pronounced a course of general actinotherapy should be given Turrell has secured good results by the use of diathermy Eight to twelve hundred milliamperes should be given for thirty to forty min

utes with one electrode on the lumbar region and the other applied over the ovaries. The plate should be about five by eight inches. The treatment is begun a week before the expected period and continued daily until *menstruation begins*.

Dysmenorrhea.—Lewis Jones and Cumberbatch advise the employment of static charge with effluve to the lumbar spine beginning a week or ten days before the period and discontinuing the treatment at its onset.

Turrell has secured results with direct diathermy, using a large indifferent electrode over the lower back and a smaller active electrode over each ovarian region in turn, 2,000 milliamperes for ten minutes in each region. Treatment should be instituted three days before, and may be given during the period if the pain is severe.

Exercise.—Mosher, Drew and the writer have repeatedly emphasized the fact that women must be taught to regard menstruation as a perfectly normal function and not as an illness. The value of light exercise during the entire period in the absence of real pathology has been proved.

Many cases are due in part to faulty posture, improper clothing, constipation and other conditions which must receive attention. Warm bathing is not only safe but advisable.

Walking, class room exercises, light floor work and tactics should be given without interruption. Violent athletics should *generally be interdicted* for two or three days.

Special exercises should be given to all severe cases. The effect of this exercise treatment in a large group of college women, reported by Clelia Mosher of *Leland Stanford University*, has been to shorten the total length of the period, diminish the pain and improve the mental attitude of the patients.

The patient is placed in the supine lying position, knees flexed. One hand without pressure or a small book is then placed on the abdomen. The patient's attention is directed to the raising and lowering of the abdominal wall to the greatest possible degree without straining by slow, deep respiratory movements. Thus the diaphragm is used as a suction pump to deplete pelvic congestion. Five to ten repetitions of the exercise are advised morning and night every day including *the menstrual* period.

Endometritis.—Few conditions are more satisfactorily treated than this one by electrotherapeutic measures. Except in the presence of placen*tal tags, ionization has every advantage over curettage* in the treatment of endometritis. It is more safe and less inconvenient, requiring no special preparation, hospitalization or loss of time. Every part of the endometrium is reached, every crypt of the mucous membrane is penetrated.

W. J. Turrell emphasizes the necessity for employing a correct technic. He surrounds the patient's lower abdomen with a bath towel wet with saline and binds on the metal pad completely around the body over the

towel The metal pad is then connected to the negative pole of the galvanic machine Zinc or copper sounds may be used as the positive pole The former are chosen when the septic discharge is pronounced and the latter in cases where there is much bleeding The sound selected is insulated in its vaginal portion by rubber tubing Turrell treats cervical erosions at the same time by wrapping a piece of absorbent cotton soaked in a 2 per cent zinc sulphate solution around the sound and applying it to the os The patient is placed in the Sims position, the sound carefully introduced and the current turned on very gradually Twenty to thirty milliamperes of current are used for fifteen minutes If pain occurs the current should at once be reduced Cases which develop severe ovarian or tubal pain during treatment should be referred to the surgeon at once for a thorough reexamination If any difficulty is encountered in the removal of the sound Cumberbatch has suggested reversing the current for a short period of low intensity This will permit easy withdrawal He and Sloan use a glass speculum.

Cervical Erosions—The technic of treating this condition by zinc ionization with the galvanic current has just been described in the treatment of endometritis

The perfection of the quartz speculum now permits the application of ultraviolet light directly to the cervical lesion One or two minutes in direct apposition should be given from the water-cooled lamp with light daily increase in the time of the exposure

Improved circulation may be secured by the application directly to the cervix of the high frequency vaginal electrode By the use of this internal electrode and a surface plate electrode about six by eight inches in size a direct diathermic current may be given which will greatly hasten the healing of old lesions Eight to twelve hundred milliamperes are used for twenty minutes The surface plate may be applied to the lower abdomen and lumbar spine at alternate treatments

Infantile Uterus—Professor B C Hirst of the University of Pennsylvania has described a technic which has been very successful in the development and restoration to function of the infantile type of uterus It is usually preceded by cervical dilatation and a course of corpus luteum and pituitary extract which alone often give no results He bases his work on the theory that the uterine muscle can be developed by electrical stimulation as can any other atrophied or poorly developed muscle His technic is as follows

A copper electrode is inserted into the uterine cavity with the necessary aseptic precautions A large pouch electrode is placed over the abdomen the patient is then given galvanism with the negative pole in the uterus 9 to 12 milliamperes This is followed by rapid and slow faradism finally by the sinusoidal current the treatment continuing for twenty minutes and being applied every other day intermitted in case

the menstruation occurs, but otherwise continued for about three months Results are not secured by less than six weeks' treatment No infection of the endometrium or of the appendages follows this treatment, but naturally the greatest care in aseptic technic is necessary The use of both faradic and sinusoidal is probably unnecessary

In case the cervical canal is too narrow to admit one of the copper tipped electrode made for intra uterine use, a narrow, flexible platinum electrode is employed which is practically indestructible Another result of this treatment is the permanent enlargement of the cervical canal by electrolysis so that the dysmenorrhea, which is an almost constant accompaniment of the lack of physical development, is usually permanently cured

G Betton Massey employs a similar technic, giving the intra uterine treatments but once a week He points out the contra indication for this technic in inflammatory conditions of the tubes

It would seem here, too, that the selection of either the faradic or the sinusoidal current should suffice, if combined with the constant current

Pelvic Inflammatory Conditions—Sperling obtained 56 per cent of subjective cures and 43 per cent of relief of symptoms in a variety of these conditions in one hundred and ten cases He used direct diathermy Continued treatment was required in some cases

The greatest care must be exercised to exclude cases in need of surgical intervention on the other hand, much may often be accomplished in many cases unrelieved by palliative procedures

Great relief often follows prolonged radiant light of high candle-power followed by gentle, long-continued diathermy, which may be given by means of anterior and posterior surface plates or by alternating them and using the vacuum or non vacuum vaginal electrode as the other pole Thirty to forty minutes' use of a current of 600 to 1,200 milliamperes is indicated

Many cases of low grade chronic inflammatory conditions are associated with a persistent chronic passive congestion of the entire adnexa These patients do not take the general exercise which increases the respiratory excursions of the diaphragm and tends mechanically to relieve this congestion There should, therefore, be given in association with the radiant light and diathermy, gentle deep respiratory exercises of the abdominal type, two or three times daily The patient should be in the dorsal recumbent position with knees raised and take five to fifteen deep respirations

As soon as local tenderness and pain are relieved the patient should be encouraged to take light exercise of a general type Cases complicated by chronic constipation may, as soon as the cessation of local tenderness permits, begin the series of abdominal exercises outlined in the treatment of that condition

Enuresis.—A toning up of sphincteric muscle and nerve control sufficient to abate this condition has often been accomplished by electrical stimulation.

Turrell employs a coarse wire faradic current, applied to tolerance, by electrodes placed on the perineum and lumbar region for ten minutes.

In adults the application of the static induced current from the negative side of the static machine by means of a rectal electrode, has given good results in a number of cases. A slow surging current is used for ten to fifteen minutes.

Gonorrhea.—In the *female* this disease is often extremely resistant to treatment. Kyaw has found the organisms to be killed in six hours at a temperature of 40° C, in three hours at 42° C and in one hour at 44° C. His patients withstood a temperature under diathermy of 44.5° C for hours without harm. He used one vaginal and one surface electrode for three hours, at times extending the time to nine hours with three hours intermission. The temperature may be checked by thermometers in vagina or rectum. No other writer employs such lengthy treatments or speaks as certainly of obtaining a cure.

Von Buben reports a number of cures by the use of diathermy in cases which were resistant to other methods.

Zinc or copper ionization by the technic described for endometritis has been used with success by Cumberbatch and others.

The combination of Kyaw's intensive diathermy regime, with direct irradiation by ultraviolet light from the water-cooled lamp by means of the quartz speculum should prove an efficient means of treatment.

In the *male* the late W. J. Morton used a zinc or copper ionization of the entire urethra. Breiger of Berlin employs prolonged radiant light directed on the urethra.

Diathermy has been applied with one surface suprapubic and one metal sound electrode, using low currents of 100 to 300 milliamperes for thirty minutes. Great caution is necessary with this technic.

Complicating orchitis and epididymitis are treated by radiant light and diathermy, a cup-shaped electrode being applied to the scrotum with the indifferent electrode on the lower abdomen.

Prostatitis.—Certain types of this disease can be efficiently treated by physiotherapy. Malignancy must be ruled out. Simple boggy enlargement yields most satisfactorily to the application of the Morton wave current applied per rectum. In dense fibrous infiltration only the accompanying edema can be relieved.

Massage of the prostate can in no other way be as well or conveniently done as with the Morton wave current. This indication is so common that it is surprising that this best of all methods has been so greatly neglected by the profession. The wave rate should be given at two per second. This method is painless, cleanly and thorough in its results. The metal rectal

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copper wire about its shank near the attachment end the wire acting as a conductor The other end of the wire is attached to the cathode binding post

The aspirating needle attached to its aspirator as well as to the electric apparatus is carefully inserted into the cyst and the contents of the latter withdrawn A fully developed cyst, with little or no parenchymal tissue overlying it, usually collapses at this time The needle, still in position within the cyst, is detached from the aspirator and employed as a cathodic electrode, 10 to 15 milliamperes of current being turned on for ten minutes This will produce a frothy liquefaction of the tissue in immediate contact with the needle making subsequent insertion of the ionizing probe easy after the current has been turned off and the needle removed

At the completion of the aspiration and the electrolysis of the sinus the wire to the indifferent electrode is changed to the cathode binding post and a short zinc probe with fine point made from one thirty second inch zinc plate, is freely coated with mercury by amalgamation, attached to the anode binding post by fine wire and inserted into the sac through the needle opening A current of 5 to 15 milliamperes is then turned on and maintained for a quarter of an hour The site of puncture is dressed, after the application and daily thereafter with dilute zinc oxid ointment and gauze The patient may remain ambulant

In three days a second ionization with mercury on the zinc probe is applied through the opening in the tiny slough At the end of a week or ten days the skin slough will be found loosened revealing a minute sinus leading into the cyst through which additional mercury ions should be diffused every third day from an amalgamated zinc probe passed into the sac. At the end of the third week the zinc probe should be insulated with fused sealing wax before amalgamation the insulation leaving a half inch at the point bare The purpose of the insulation is the protection of the sinus walls from further enlargement by confining the ion diffusion to the sac itself During the course of the treatment the later insertions of the ionizing probe are made less painful by placing a drop of cocain or procain solution on the opening five or six minutes prior to its insertion All ionizations are of fifteen minutes duration with a current strength dictated by the sensitiveness of the patient, of between 3 and 10 milliamperes The final ionizations during the fifth to the seventh week are not much more than probings with a little current for sterilization, until the wound closes fully from the bottom This technic may be varied by making a free opening with a small bistoury and immediate ionization at the first application or by the use of the mercury ion alone held in amalgamation on a solid gold probe The use of the zinc ion in association with the mercury ion as described above is thought however to be more quickly destructive of the cyst wall than

electrode may be inserted by the patient and is easily retained The positive pole of the static machine is used with the terminal separation slowly increased as the tolerance of the patient permits

Painful inflammations are best treated by diathermy using a rectal metal or non vacuum glass electrode and a surface plate on the abdomen. Six to twelve hundred milliamperes are used *for twenty minutes*

Victor C Pedersen of New York, reports a number of cases of gonorrheal prostatitis in different stages in which most satisfactory results were secured by electrotherapeutic measures He uses the high vacuum glass prostatic electrode attached to the negative pole of the static machine The use of a short spark gap of one inch proved soothing in acute cases Where deep massage is indicated the positive pole and wide spark gap is used

Nephritis—In acute nephritis the stimulation of the excretory function of the skin is all important The radiant light cabinet bath or body bath, with superheated dry air with the patient recumbent, is one of the most efficient methods we have of accomplishing this result

These treatments should be given at a relatively low temperature and may be continued for several hours when necessary The value of this procedure in hospital practice can hardly be overestimated

It would seem logical that in certain cases diathermy of the kidney should prove of value The writer used this method in three cases which were in a state of coma Two were apparently quickly and markedly improved and made a complete recovery from the attack The other case was *not improved* *No estimate of its value can be made from these* results other than the fact that they would seem to justify further employment of this measure A large plate, about six by ten inches, was placed on the abdomen and a smaller one, four by seven inches, over each kidney, in turn, using 1,200 milliamperes for twenty minutes on each

DISEASES OF GLANDS DISEASES OF THE EAR, AND SCARS

Cystic Goiter—G Betton Massey of Philadelphia uses drainage and ionization to destroy the sac A preliminary aspiration is made to confirm the diagnosis and *only those cases with fluid present* are treated by this method

With the patient recumbent on the operating table, an indifferent pad is placed beneath the back and connected temporarily with the anode of a direct current apparatus The skin over the most prominent part of the cyst is anesthetized over an area of about a square inch by endermic injections of a 2 per cent solution of either procain or apothesine, and a rather large aspirating needle is prepared to function as a cathode, as well as an aspirator, by winding the end with a sufficient length of No 34

been done to warrant definite conclusions It seems, however, as logical to stimulate a poorly functioning gland by means of diathermy, the effect of which measure can be so definitely localized, as to supply artificially the body with the gland extracts Already attention has been directed to the possible effect of X ray upon various glands of the endocrine system

Otitis Media—In the beginning of the acute stage the immediate and intensive application of radiant light is one of the most satisfactory procedures in the whole range of physiotherapy If taken sufficiently early, the inflammatory condition may often be immediately stopped In later cases indications for puncturing the drum remain as usual but radiant light should be applied and persisted in, whether or not this procedure is necessary Any form of electric light, even the ordinary incandescent bulb will serve in an emergency for home treatment The hundred candlepower hand lamp placed on a pillow, eighteen or twenty inches from the head, is very efficient Few cases so treated from the beginning will go on to suppuration or mastoid involvement The effect upon the patient has been described by otologists who have used it extensively, as being out of all proportion to the amount of heat developed in the aural canal

In chronic cases A P Friel of the London Royal Hospital, states that zinc ionization is a method by means of which the tympanum can be disinfected without irritation and a large proportion of his uncomplicated cases cleared up in one or two treatments Both ultraviolet light and diathermy have been used in chronic middle ear disease with varying degrees of success With a cuff electrode around each wrist and the patient s little fingers inserted into the external auditory canals a mild diathermy can be passed directly through the affected region About 300 milliamperes should be used for fifteen minutes This should be followed by local application of ultraviolet light through a small sinus applicator inserted part way into the canal Success by these methods depends upon the amount of destruction that has taken place and there can be no question that they are distinct adjuncts to the routine procedures

Catarrhal Deafness—One useful adjunct in the treatment of this condition is the application of slow, gentle, sinusoidal current after the technic of William D McFee of Haverhill A metal electrode is placed on the tongue and a pledget of cotton soaked in saline and wrapped around a small electrode is gently placed in the ear A gentle and efficient massage of the drum is obtained by the use of a very moderate amount of current, easily tolerated by the patient for ten to fifteen minutes

Scars—The minimizing of the amount of cicatricial tissue formation is one of the best accomplishments of modern surgery The excision *en masse* of infected and macerated tissue was one of the essential lessons of the War The physiotherapist is concerned in so modifying the remaining scar tissue as to make it as little of a handicap as possible in the motor life of the patient The functional results secured by a regime

the mercury ion alone. But, in any case, the mercury ion is essential to the method, on account of its high antiseptic action.

Exophthalmic Goiter.—S. Solis Cohen concludes that, because of the varying and little known pathogenesis of this disease, no single method of treatment will ever suffice in all cases. He divides them roughly into the highly toxic type, where the ocular, cardiac and nervous symptoms predominate and the gland is distinctly hyperactive, and a sluggish type, in which gland function is not hyperactive regardless of its size.

Brustad, Snow, Massey and other writers report favorably upon the effect of the galvanic and Morton wave current in various types of goiter. In our small group of cases of the active toxic type, we have used negative galvanism and static effluve with good results, but in too small a number of cases to form a definite judgment of the general value of these procedures. In the absence of hyperthyroidism, ionization from potassium iodid, using the negative pole, has produced good results. Cohen uses the static sparks and static resonator effluve directly on the gland in this type of goiter. These indicated conservative methods, together with others not within the scope of this writing, should logically be tried before radical surgery, except in those rapidly developing cases of toxic type in which it may still be safe to operate.

Adenitis.—In both simple and tuberculous adenitis of the cervical glands, attention must be directed to the possible removal of tonsils and adenoids, hygienic and other indicated procedures. In the treatment of tuberculous adenitis, Miller reports the results from a regime of heliotherapy, as given in the combined French Sanitarium reports, as 74 per cent cured. Hyde and Lo Grasso report 78 per cent of cures in some two hundred cases treated by the same method. The carbon arc and ultraviolet light have been used with similar results. There seems to be a preponderance of opinion that conservative measures should be thoroughly tried out before resorting to operation. Glands in the superficial chains should be treated by compression with the surface applicator from the water cooled lamp. General irradiation with the air-cooled lamp is advisable. Results by this method have been very satisfactory where the main foci of infection were removed. Persistent sinuses may be healed up by the combined surface and internal administration of water-cooled ultraviolet light through the sinus applicators.

In several cases of inguinal adenitis in various stages, the local compression application from the water cooled light yielded excellent results. Glands that had begun softening before light was applied were found, upon later incision, filled with serum instead of pus.

The Ductless Glands.—The subject of the endocrine system and the various disorders of function to which it is subject, forms too large a topic to be discussed in detail here, and too little work of scientific value in the application of physiotherapeutic measures to these glands has yet

been done to warrant definite conclusions It seems, however, as logical to stimulate a poorly functioning gland by means of diathermy the effect of which measure can be so definitely localized, as to supply artificially the body with the gland extracts Already attention has been directed to the possible effect of X ray upon various glands of the endocrine system

Otitis Media —In the beginning of the acute stage the immediate and intensive application of radiant light is one of the most satisfactory procedures in the whole range of physiotherapy If taken sufficiently early, the inflammatory condition may often be immediately stopped In later cases indications for puncturing the drum remain as usual but radiant light should be applied and persisted in, whether or not this procedure is necessary Any form of electric light, even the ordinary incandescent bulb will serve in an emergency for home treatment The hundred candle-power hand lamp placed on a pillow eighteen or twenty inches from the head, is very efficient Few cases so treated from the beginning will go on to suppuration or mastoid involvement The effect upon the patient has been described, by otologists who have used it extensively as being out of all proportion to the amount of heat developed in the aural canal

In chronic cases A R Friel of the London Royal Hospital, states that zinc ionization is a method by means of which the tympanum can be disinfected without irritation and a large proportion of his uncomplicated cases cleared up in one or two treatments Both ultraviolet light and diathermy have been used in chronic middle ear disease with varying degrees of success With a cuff electrode around each wrist and the patient s little fingers inserted into the external auditory canals, a mild diathermy can be passed directly through the affected region About 300 milliamperes should be used for fifteen minutes This should be followed by local application of ultraviolet light through a small sinus applicator inserted part way into the canal Success by these methods depends upon the amount of destruction that has taken place and there can be no question that they are distinct adjuncts to the routine procedures

Catarrhal Deafness —One useful adjunct in the treatment of this condition is the application of slow gentle sinusoidal current after the technic of William D McFee of Haverhill A metal electrode is placed on the tongue and a pledget of cotton soaked in saline and wrapped around a small electrode is gently placed in the ear A gentle and efficient massage of the drum is obtained by the use of a very moderate amount of current, easily tolerated by the patient for ten to fifteen minutes

Scars —The minimizing of the amount of cicatricial tissue formation is one of the best accomplishments of modern surgery The excision *en masse* of infected and macerated tissue was one of the essential lessons of the War The physiotherapist is concerned in so modifying the remaining scar tissue as to make it as little of a handicap as possible in the motor life of the patient The functional results secured by a regime

of physiotherapy often determine whether or not a second excision of the cicatrix is necessary

The aims of the employment of physical measures on scar tissue are

1 To promote increased vascularization
2 To decrease the density of the fibrous tissue
3 To free surrounding structures, nerves, tendons, muscles and ligaments from cicatricial adhesions
4 To increase the thickness and strength of the newly formed epidermis All physiotherapeutic technic applied to scar tissue must be very carefully graded for optimum effect Only a few of the measures and none of the dosages indicated for normal tissue may safely be employed

By the use of properly graded doses of galvanism from the negative pole we may accomplish two or three of our indications It will be remembered that *the action of this pole is to soften and liquefy scar tissue* and to promote vascularity The first effect would naturally also aid in freeing other structures imbedded in the scar The chlorin ion is an additional aid in accomplishing this result, and a slightly stronger salt solution may be used on the negative pole than is necessary on the positive to secure easy conduction of the current The active electrode covering the scar must be prepared with unusual care See that it is thoroughly and evenly moistened and its surface smoothly applied to all parts of the scar The current of 5 to 15 milliamperes should be employed for from thirty to forty minutes and the electrodes will probably need remoistening during the treatment

Radiant light from either the high or low-candle power lamp, placed at half again the distance usually used, will promote the vascularity of the newly formed integument The ultraviolet light from the air-cooled lamp, in mild and often repeated doses, will stimulate skin cell growth This should be given with the all mercury burner, at about thirty inches for one minute with fifteen seconds' daily increment With the mercury tungsten burner it should be applied at a distance of forty inches with ten seconds daily increase Diathermy is an aid to both the softening and vascularization of the cicatrix and should be applied by the cuff or zone method above and below the involved area The impoverished circulation in dense scar tissue means poor and sluggish diffusion of heat, therefore a low current strength of 300 to 500 hundred milliamperes and sufficient area of the electrodes should be selected so that the current density will not be over 50 milliamperes per square inch

For the purpose of loosening the scar from surrounding structures no apparatus quite approaches in effect the use of the heavy long stroke motor vibrator The vibrations are given around the scar, working centrally as far as tenderness will permit Static sparks, Morton wave, mas-

sage and even at times the sinusoidal current may be employed for similar effect The use of intensive local heat from superheated dry air or the paraffin bath is apt to produce large blisters and destroy the newly formed skin

POSTURAL DEFECTS

The effect of faulty posture in lowering the working efficiency of the individual is pretty well established Marked increase in total fatigue ensues when the mechanics of weight bearing are faulty The functions of the respiratory system and gastro intestinal tract are interfered with to a large degree by the habitual assumption of bad posture Visceroptosis is often due primarily to this cause It is the opinion of the writer that many of the so called organic or structural orthopedic types of spinal defect, typified by scoliosis are nearly always postural or flexible in type at first but become fixed by the effect of long continued habitual malpositions of the soft tissues Only in associated calcium deficiency or cases of severe degree and long standing do bony changes occur This point emphasizes the value of early treatment

The correction of faulty posture especially in school children lies distinctly in the field of preventive medicine as well as in that of therapeutics Physicians, parents and educators are not yet fully awake to the vital importance of this subject

The general indications are the same in nearly all of the types of postural defects, they are

1 To reeducate the muscle sense to the correct attitude
2 To improve the muscle tone and vigor of the entire body
3 To stretch those muscle groups which have been allowed to shorten by the defective carriage
4 To strengthen and thereby shorten the physiological opponents of the contracted group
5 To increase the general flexibility and maintain the full range of movement in the joints

To accomplish these results we employ orthopedic and general exercises massage and electrotherapy Other physical measures considered in their respective sections are used when rickets or infantile paralysis are associated conditions Much space is given to the severe types of deformity in the orthopedic texts but very little information on the causes diagnosis and treatment of the very common postural defects appears in the literature For this reason a brief general discussion of each type of defect is given with the treatment regime.

Head and Shoulders—The combination of round shoulders and forward position of the head is the most common postural slump Defects of hearing and vision and improper sitting in school are the greatest causes of the poor posture In slight degrees of round shoulders, the lower angle of the scapulæ, only, may be prominent In the more severe types the entire inner border assumes the "winged scapulæ" position The correction of the head position is secured by the exercises of head retraction The child thrusts the head forward chin up, and retracts the head slowly and forceably bringing the chin down This may be made a resistive exercise by the child supporting himself by the hands, arm's length from a wall, the operator standing behind him and resisting the head retraction, hand or hands placed behind the child's head A great deal has been written about the fundamentally correct posture Many of the directions given are too intricate for a child to follow The single command to raise the sternum to the utmost height will automatically bring the child into the correct posture The cooperation of parent and teacher to insist continuously upon the correct attitude is essential in the formation of correct postural habits The correction of the round shoulders is obtained by the use of the group of shoulder exercises considered in the next topic Shoulder braces remove all exercise from the already weakened upper back muscles and often obtain their fixations on the movable lumbar spine inducing lordosis They should be avoided, if possible

Kyphosis—This position of increased flexion of the dorsal spine is nearly always accompanied by round shoulders It may be considered simply as a greater degree of the former in which the spine plays a part The etiology is the same, but there is usually some definite weakness of body structure as well Such lack of tone as accompanies undernutrition too rapid growth or intercurrent illness, etc, is associated with some repeated strain on the body's structure

Round Shoulder and Kyphosis Exercises

1 To reeducate muscle sense
   - *a* Place child before mirror Assist him in assuming the correct posture
   - *b* While he attempts to retain good posture, march him around the room and return to mirror, making necessary corrections in attitude
   - *c* With his back to the mirror, the child is instructed to assume the correct attitude is faced toward the mirror and attempts his own correction

2 To improve general muscle tone
   - *a* General light class exercises
   - *b* *Athletics and games in moderation without exhaustion*

3 To stretch the contracted pectoral muscles
   a Child seated on stool, hands to neck operator places foot on stool behind patient, knees against dorsal spine and makes retraction on elbows
   b Child stands in front of stall bar uprights, grasping behind shoulders Keeping head shoulders and hips in contact he performs a deep knee bending and straightening
   c Child lies supine on plinth or narrow bench Hands behind neck, operator from above presses down on elbows
   d Child suspended by hands from bar or ladder, operator places hands between scapulæ and presses firmly forward
   e Child in front of horizontal or parallel bar, or behind slanting ladder grasps shoulder high arm s length in front Without moving feet he falls forward to full arm hang
   f Pupil with spread grasp raises wand above head, lowers behind shoulders

4 To strengthen the stretched and weakened upper shoulder group
   a. Arms forward raise sideward carry and slowly sideward lower keeping shoulders well back
   b Arms forward raise forward bend (hands to chest, elbows raised and well back) Sideward lower with shoulder retraction
   c Arms forward raise obliquely side-upward carry sideward lower, slowly maintaining shoulder retraction
   d Arms forward bend as before trunk lower forward hands thrust forward and carried sideward in imitation of breast stroke swimming
   e Rotate arms completely outward forcing shoulders back.

5 To increase general flexibility
   a Hands suspension spine twisting right and left by turning pelvis
   b Stride stand arms sideward raise trunk to the right bend raise, to the left bend raise
   c In same position trunk to the right turn, return to the left turn, return

Lordosis—Abnormal forward curve in the lumbar spine is often associated with and compensatory to kyphosis High heels and excessive abdominal weight are also causes of this condition The increased lumbar curve and pelvic inclination adds to the strain on the anterior abdominal wall which may become relaxed and weakened This is one of the contributing factors to visceroptosis and chronic constipation and adds greatly to fatigue in standing

Exercises for Lordosis

1 To stretch the shortened lumbar erector spinæ
 a Long sitting, legs extended in front.
2 To strengthen the abdominal muscles
 a Supine lying, hands at sides palms down, double knee bending and straightening
 b Double leg raising and lowering slowly
 c Sitting up and lying back.
 d Flex knees to chest, extend feet over head raise pelvis from the table and return.
 e Flex and extend knees alternately and rapidly in imitation of bicycling
 f Hands suspension, double knee raising

Scoliosis—Nearly 20 per cent of children show some degree of scoliosis. In the examination of from one to two thousand preparatory school girls I found about 22 per cent had lateral curvature Like every other condition it is difficult to diagnose but easy to cure in its incipiency Those curvatures which straighten out on hand suspension have been termed functional flexibility or postural," curves, the others "structural or organic Postural cases outnumber the structural type by about ten to one, but are often overlooked in hasty physical examinations.

In addition to the causes mentioned under anteroposterior deformities most of which apply here as well, we have unilateral weight bearing and infantile paralysis affecting the back as common causes Most curves start as single C shaped curves and, if untreated, often develop into double or S-shaped deformities due to compensatory straightening of the pelvis or head

Many patients carry slight scolioses through life with no ill effect but they are sources of very great potential danger I have seen slight curves become great in degree and fixed in character very quickly following wasting illness infections of the rheumatic group and other conditions which suddenly lower the body's resistance Many schools and colleges are now thoroughly examining for postural defects and following out carefully prescribed individual exercises. When this procedure is universal a great deal of deformity now present will be prevented Such examinations should be started in the grammar school

Diagnosis.—In the examination of the back we rely upon the following five signs

1 *The scapula tends to be higher, more prominent* and further from the dorsal convexity
2 The arm waist angle is less on the side of the curve
3 The shoulder on the convex side is usually higher and the hip on

the lumbar convexity less prominent when compared with the opposite side

4 The marked spinous processes show a deviation from the plumb line in all pronounced curves In slight ones absence of this sign does not rule out a curve

5 Prominence on one side in the mid-dorsal or lumbar region brought out by trunk forward bending is a sure sign of vertebral rotation and is the most reliable evidence of scoliosis A prominence indicates a curve to that side in the region in which it occurs

The subject of vertebral rotation has caused more disagreement than any other phase of this condition It can positively be stated that there is no lateral displacement without some degree of rotation and it is proportionate to the amount of lateral deviation

All orthopedists agree that in an advanced fixed curve the bodies rotate toward the convexity thus turning the spinous processes back toward the normal position and masking to some extent the amount of the curve and, at the same time, causing the ribs to become prominent on the affected side

There is no such agreement in regard to the rotation occurring in a flexible curve Lovett of Boston has contributed more than any other single individual to our knowledge of the subject His experiments on a model performing trunk bendings sitting on inclined seat, etc, seem to show that in a normal lateral trunk bending the bodies do rotate toward the concavity of the curve produced This hypothesis he applies to flexible lateral curvature as being the same thing In his teaching the writer has stated the cause of rotation to be primarily the result of the fact that when a column of blocklike bodies is displaced in part so that the center of gravity does not fall through the center of all the bodies, those so displaced rotate away from the line of weight bearing So in a left total curve the thick front of the vertebral bodies rotates to the left away from the center of gravity which now falls to the right of their center No such force is at work in a normal trunk bending moreover flexible curves are slight and hard to detect because the amount of lateral displacement is nearly equaled by the rotation so that the spinous processes fall very nearly in the midline If reverse rotation took place in these cases the spinous processes would swing widely out and their line the apparent curve would be greater than the displacement of the centers of the bodies of the vertebræ (the real curve) and the diagnosis easy Furthermore as a curve is becoming fixed and the re-rotation claimed by those who hold this theory taking place the apparent curve would necessarily become less when as a matter of fact we know that in untreated cases the tendency is for the curve to increase It is believed that a flexible curve becomes rigid first by the sclerotic changes induced in the muscles allowed

to maintain contraction on the concave side, then by changes in the ligaments and *intervertebral discs, and lastly, and only if bony softening is* present, the bone becomes distorted At what point in this gradual "setting" process does re rotation begin? Given two left total curves of the same amplitude in two patients of equal age, one of which straightens out under suspension, the other not, does it seem logical that a diametrically opposite rotation should occur in them?

I have gone rather deeply into the subject of rotation because proper treatment is dependent on a knowledge of it The bodies would rotate still more were it not for the fact that the articular facets are set in different planes The flexion of the spine forward unlocks the articulations and allows increased rotation to take place, thus bringing out the prominence on the back

The treatment of scoliosis is not extremely difficult nor does it require cumbersome and complicated mechanotherapeutic apparatus which is being less and less used in physiotherapy

Exercise is taking first place and gaining favor as our main dependence and should always be used between casts if they be deemed necessary

1 Exercises to reeducate the muscle sense
   a Use mirror as in kyphosis Place emphasis on *erect head,* even shoulders and hips
   b Return to mirror at the end of the exercise program, having child attempt good posture with eyes closed and make self correction
   c Teach the position of "self-correction" in each individual case This position consists of stretching vigorously obliquely side upward the arm on the dorsal concavity and the opposite hand is worked as far back as possible and pressed on the lumbar concavity, in total curves In double curves the child's hands are pressed against the body in the posterior axillary line, the upper against the dorsal and the lower against the lumbar convexity

2 These children also should do general setting up work and bilateral *muscle strengthening*

3 Stretch the muscles on the concave side
   a The child assumes his self correction attitude and with hips fixed against some convenient object, such as a table, bench or chair, performs lateral trunk bending toward the lumbar concavity
   b With grasp on stall bars or horizontal bar, chest high the body is lowered to full arm's length, both legs toward the lumbar convex side
   c *Spring sitting at side of stool, trunk inclined forward,* the arm

on the side of the dorsal concavity is stretched vigorously forward and the leg on the side of the lumbar concavity is stretched backward to the fullest extent

d The child assumes the self-correction attitude and walks several steps on tiptoe, stretching the spine to the utmost

e Hook lying supine on table, knees over the edge, both hands overhead Operator stands behind pupil grasping both hands, stretches spine fully

f The child hangs suspended from bar, operator from behind exerts counterpressure on dorsal and lumbar convexities pushing child forward

g Strap table Shoulders and pelvis strapped toward the convexity in those regions two central straps exert traction from below and toward the concavity

4 To increase flexibility exercise for spinal flexibility as given under Kyphosis

Other Physiotherapeutic Measures—In all cases of long standing the muscles on the concave side tend to become first spastic and later undergo chronic fibrous myositis These changes can be to a large extent prevented by the use of radiant light and heat high frequency Morton wave and static sparks and massage with the same technic already given for these modalities In severe cases requiring casts the value of these measures coupled with exercises cannot be overestimated The circulation within the muscles and their general tone becomes greatly impaired under the cast, and a period of intensive physiotherapy should be given before putting on another cast

All of these exercises need not be given in a single program but at least one from each different group must be chosen to meet all indications The stretch walk and spring sitting exercises should be taken with the utmost intensity for only brief intervals of time

FOOT DISABILITIES

This group of conditions most of which consist in the last analysis of toxic atrophic, or traumatic myositis or arthritis, are especially amenable to treatment by physiotherapy which may lead to complete restoration of function The accepted orthopedic measures of providing arch supports, on the other hand, more often attain symptomatic relief rather than cure A brief review of the etiology and modern methods of treating these common and disabling conditions is well worth while

The foot is designed to support the body and to enable it to move over various kinds of surface Those who still use their feet in natural fashion

have strong and well-developed muscles and ligaments, broad forefeet, and grasp with facility uneven surfaces upon which they walk. The fact that in standing and walking they point the feet straight forward or slightly inward is of importance.

A study of the changes in the use of the feet induced by modern civilization, and the conditions under which they must do their work, will reveal some of the reasons for the great prevalence of foot disability.

In the first place, we teach our children to evert the feet. In this posture the weight is transmitted to the inside of the foot over the arch, instead of through the forefoot. Armitage Whitman believes this attitude to be the underlying cause of weak feet. It is obviously one of the important factors in bringing about this condition. In walking with feet everted, the outer side of the heel first strikes the floor, then the weight is transmitted diagonally forward and inward to the arch, causing a severe cross strain. If high heels are worn when the feet are everted, the strain becomes very greatly increased.

We incase the feet in shoes, not one of which is the shape of the human foot. Certain requirements must be met to reduce to a minimum the deforming influence of the shoe. It must have a sole sufficiently thick to protect the foot from the stone pavements on which we are condemned to walk, and to prevent the sides of the sole from curling up, making a hollow into which the anterior arch tends to fall. The toe cap should be full enough to allow free movement of the toes. Such point as the shoe possesses should be in front of the great toe and not in the middle of the foot, which crowds the big toe into the hallux valgus position. The shoe must at all times be long enough to prevent the toes being cramped. Hammer toes often develop in children whose feet grow in length before the shoes are worn out.

The heel is a vital factor in proper shoeing. Especially is it necessary to have a heel with a reasonable amount of cross surface. Otherwise, with any height it becomes a stilt, on which the patient is doing a finely coordinated and very fatiguing balance exercise, using groups of muscles in which the circulation is poor and therefore recovers from fatigue slowly. With the high heel also there is a tendency for the forefoot to become crowded forward and bear undue weight, as the instep resting on the steep slope of the shank cannot support its share of the weight. Lastly, and perhaps most important, is the tendency of the high heel to throw the calf muscle group into a state of partial contraction, which position if long held becomes a factor in the structural shortening of these muscles, producing muscle-bound feet. Lovett calls attention to the fact that the arch of the sole of the shoe is often too low to support that of the foot and is, therefore, one of the causes of foot strain.

In addition to the exercise-preventing and deforming influence of the shoe, we have added the hard wood floor and cement pavement for full

measure The wonder is not that there is so much foot trouble, but that it is not universal

Poor mechanics of walking adopted to avoid pain from corns callosities sprains, etc must be recorded among the causes of foot strain

I have had many cases which verify the point so well brought out by Henry W Frauenthal of New York that the toxins of recent disease or specific infection as well as those from foci of infection in teeth, tonsils etc play a leading role in painful foot disabilities The influence of these toxins in retarding recovery, when there is some other more obvious cause present as well, is constantly overlooked

We have then the foot predisposed to strain by the impossibility of normal development used improperly and attacked by the toxins of disease, causing the patient to seek relief It is quite the usual thing for him to pass through the hands of several shoe store foot experts' and a few chiropodists before reaching the physician If the trouble is entirely local the foot appliance provided for the patient will often give marked relief It is because such plates etc are not curative as a rule in the long run, and because of the very frequent presence of other than local cause that a real cure is seldom attained

In considering diagnosis a further point made by Frauenthal is of value He states that when pain in the feet comes on suddenly we must suspect injury or infection whereas if the onset of symptoms is gradual there is strain of muscles or ligaments E A Rich of Tacoma, Washington records the arch impression and compares it to the amount of ankle valgus pointing out how often painful feet occur with marked valgus of the ankle and with cavus rather than with planus deformity Lovett found no change in the arch impressions of a large number of the eight hundred nurses he pedographed after the onset of pain in the feet He refutes the accepted theory that there is necessarily an elongation and broadening of the sole of the foot in these conditions I have never felt that the taking of an arch impression was essential to diagnosis

In the examination of the forefoot sharply localized pain under the second third or fourth metatarsophalangeal joint is indicative of anterior arch trouble, but may point to an inflamed or broken sesamoid or to osteo arthritis from any cause Occasionally we are dealing here with pain referred from the main arch

When the pain is located in the longitudinal arch under the scaphoid the presumption is that this arch is under strain It is important to remember that strain is often present in the naturally high arch before there is any sign of flattening and is due to tension at the periosteal attachments of the ligaments or in the plantar muscles

Examination is never complete without testing the dorsal flexion of the foot Have the patient sit with knees fully extended Grasp the forefoot firmly, invert then flex being sure the patient's muscles are

have strong and well developed muscles and ligaments, broad forefeet, and grasp with facility uneven surfaces upon which they walk The fact that in standing and walking they point the feet straight forward or slightly inward is of importance

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In addition to the exercise preventing and deforming influence of the shoe, we have added the hard wood floor and cement pavement for full

The treatment of muscle-bound feet is primarily aimed at stretching out the calf muscle group It is the muscle and not the Achilles' tendon that is short except in cases of severe contracture These muscles often feel hard and fibrous and are quite tender

We heat intensely with the 1 500 candle power lamp, use diathermy through the calf by lateral plates 1 000 milliamperes for fifteen minutes each and finish by prolonged deep slow effleurage Here the exercise which consists of standing feet parallel arm s length from the wall, and lowering the body forward keeping heels on the floor, is begun as soon as the deep tenderness in the muscle has lessened It is pushed as much as possible without setting up inflammatory reaction

When as often is the case we are dealing with a combination of foot strain and muscle-bound foot, we treat by a combination of the methods outlined omitting Exercise 5 These are undoubtedly the cases that Lovett states are made better by raising the heel and he points out how many times they are made worse by suddenly shifting to a so called orthopedic shoe These patients feel better with a higher heel because more slack is given the calf muscle, but the strain of walking and standing is increased and the new slack given may soon be taken up with a repetition of the symptoms

What constitutes a cure? In the case of the arch it is the removal or modification of the cause the allaying of the inflammation and the rebuilding of the tone of the muscles and ligaments to carry *without any artificial supports whatever* the weight they were designed to carry In muscle-bound feet a cure consists in the removal of the local or constitutional cause of tenderness or inflammation with the gradual stretching of the calf muscle group until a dorsal flexion of 90° or less allows the use of a moderately low heel without discomfort

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relaxed Estimate the angle between the rear of the leg and the outer part of sole This angle should be less than a right angle—75° to 85° When the flexion is limited to 90° or more you are dealing with a muscle-bound foot This condition is present in about 30 per cent of women and 10 per cent of men seeking relief from painful feet In women I believe it to be the greatest single factor in the causation of foot strain and to be in itself the underlying reason for a large part of the eversion of the feet described by Lovett This is the sequence of events In the normal step with feet straight, there is a time just before the rear heel is raised when the dorsal flexion of the foot is less than a right angle. It is at this point that a short calf muscle is subjected to undue tension which may or may not be recognized by the patient A slight eversion of the feet will relax this tension If the condition is progressive, increased eversion becomes necessary with the intense strain on the arch outlined above Sooner or later symptoms of foot strain appear

Treatment—Our attention should be directed first to the removal of the cause The acute toxic or infectious conditions are generally obvious, but it is necessary that chronic conditions and foci of infection be constantly kept in mind as factors which delay recovery The proper mechanical use of the feet and relative rest must be insisted upon where possible

Anterior metatarsalgia is treated by intensive radiant light and heat or paraffin bath, high frequency, static sparks and massage A felt pad may be strapped on or held by an anterior arch collar when necessary

In the treatment of the main arch, the Thomas heel, extended one-half to three-quarters of an inch and raised one-eighth to one-quarter inch on the inner side, is useful in nearly every case Very rarely soft felt pads under the arch, or in cavus foot under the instep, may be used Strapping with adhesive may be done as a temporary measure It has not been found necessary to prescribe any arch plate whatever in the last three years Occasionally a well fitting arch already purchased was permitted while the local treatment was being given

Where the main arch is under strain we treat by radiant light and heat, 1,500 candle-power for fifteen minutes, high frequency, or diathermy —given by means of one metal plate to the sole and the other encircling the ankle—and massage Exercise often makes these cases worse, when instituted before other means have allayed the inflammation in the tissues. For this reason exercise is delayed until the tenderness has largely disappeared A very simple set of exercises are used

1 Stand, feet parallel—roll out
2 Walk forward on outer edge, toeing in
3 Toe in and rise on toes
4 Ground gripper walk

The treatment of muscle-bound feet is primarily aimed at stretching out the calf muscle group. It is the muscle and not the Achilles tendon that is short, except in cases of severe contracture. These muscles often feel hard and fibrous and are quite tender.

We heat intensely with the 1,500 candle power lamp, use diathermy through the calf by lateral plates 1,000 milliamperes for fifteen minutes each and finish by prolonged deep slow effleurage. Here the exercise which consists of standing feet parallel, arm's length from the wall, and lowering the body forward, keeping heels on the floor, is begun as soon as the deep tenderness in the muscle has lessened. It is pushed as much as possible without setting up inflammatory reaction.

When, as often is the case, we are dealing with a combination of foot strain and muscle-bound foot, we treat by a combination of the methods outlined, omitting Exercise 3. These are undoubtedly the cases that Lovett states are made better by raising the heel, and he points out how many times they are made worse by suddenly shifting to a so-called orthopedic shoe. These patients feel better with a higher heel because more slack is given the calf muscle, but the strain of walking and standing is increased and the new slack given may soon be taken up with a repetition of the symptoms.

What constitutes a cure? In the case of the arch it is the removal or modification of the cause, the allaying of the inflammation, and the rebuilding of the tone of the muscles and ligaments to carry *without any artificial supports whatever* the weight they were designed to carry. In muscle-bound feet a cure consists in the removal of the local or constitutional cause of tenderness or inflammation with the gradual stretching of the calf muscle group until a dorsal flexion of 90° or less allows the use of a moderately low heel without discomfort.

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CHAPTER XIII

RADIUM THERAPY

THOMAS ORDWAY L WHITTINGTON GORHAM AND CLINTON B HAWN

Radium—Since the discovery of radium in 1898 this source of energy has been utilized for the treatment of a great variety of both external and internal diseases The earliest and perhaps the most useful, field of application was in dermatology and as this form of therapy proved of value in treating some of the most intractable skin diseases, such as lupus and carcinoma of the skin the result was that overenthusiastic claims were made for radium therapy even in many incurable diseases.

The literature on radium therapy has now reached enormous proportions Not only are there a great number of articles but many volumes and even journals are devoted solely to radium therapy To this literature the reader is referred for any detailed account of the subject In this chapter a mere outline of the technic used the variety of conditions which have been treated and the general results obtained can be described The therapeutic application of radium was developed by the French, notably by Dominici Wickham and Degrais The German began the use of mesothorium and elaborated other forms of radium therapy Radio-active substances and their products have such remarkable physical properties that the discovery and investigation of them has radically altered even fundamental conceptions regarding matter With this in mind and with the realization that radio active substances and their products are so varied and may be used for therapeutic purposes in the solid, gaseous or liquid form, it is not surprising that they have within recent years been the subject of extensive scientific experiment and also of widespread clinical application, even to the degree of exploitation

Degrais has suggested the advantage of calling radium therapy Curie therapy as we now speak of Roentgen therapy when the X rays are used in treatment

Mesothorium was discovered by Hahn in 190 The initial cost of mesothorium is less than that of radium but it loses its activity in very much shorter time the half life period of mesothorium being about seven years while that of radium is about ? 000 years Therefore at the present time the use of radium has for the most part replaced that of thorium

Soon after the discovery of radium by the Curies it was found that radio active substances produced effects similar in many ways to the Roentgen ray In 1901 Becquerel was burned by carrying radio active material in his pocket In 1906 the Laboratoire Biologique du Radium was established in Paris and here Dominici, Danne, Wickham, Degrais and their coworkers developed the therapeutic application of radium In 1909 the Radium Institute at London was established for the treatment of disease by radium

In Austria the government established a central station for the distribution of *various forms of radio-active material to the different clinics.* There is also in Vienna a Radium Institute supported by private funds, for the strictly scientific study of radio active substances In the United States the names of Abbe, Morton, and Kelly were early associated with the development of radium therapy In several of the larger cities, notably Boston, New York, Buffalo, Baltimore and Chicago, there are special institutes or hospitals devoted almost exclusively to research and the therapeutic application of radium Here the amount of radium available varies from 1 to 3 or more grams In only very exceptional instances, however, are such large amounts used at one time in any particular case In the great majority of pathological conditions 100 milligrams are sufficient, if properly employed, to produce such results as may be reasonably accomplished

Radium is an element in the strontium barium group Its properties are now quite generally known It is a metallic element designated by the symbol Ra Three of the commonest salts are the bromid, chlorid, and sulphate of radium It is derived from uranium Other members of the radio active group are thorium and actinium Radium is constantly undergoing transformations into other substances, that is, radium becomes successively emanation, radium A, B, C, D, E, F (or polonium) which is probably converted into lead The rate of this transformation cannot be altered by any known process or condition During these transformations, energy is radiated from the substances in the form of the so called alpha, beta, and gamma rays, upon the various effects of which the therapeutic action depends

Alpha rays are positively charged atoms of helium They travel at the rate of 20,000 miles a second Their penetration is slight, indeed, they are stopped by even a thin sheet of writing paper They may produce marked chemical change but cannot be used practically in treatment except in superficial lesions of the skin

Beta rays are negatively charged electrical ions, electrons, like cathod rays, but of about the velocity of light (186,000 miles a second) They penetrate about 8 millimeters of tissue, but do not penetrate over 2 millimeters of lead, or 1 2 millimeters of brass They also induce chemical change in organic matter

Gamma rays are not particles of matter but vibrations of the ether similar to ordinary light and to the X rays but of much shorter wave length and greater penetration. They are said to have less power than the alpha or beta rays to produce chemical change.

In medical work we may use the three sorts of rays together or by appropriate screens exclude either the alpha or beta rays. Ten per cent of the gamma rays are absorbed by 1 centimeter of tissue. They readily pass through 1.2 millimeters of brass, only about 3 per cent being absorbed. In passing through metal screens, however, soft secondary beta rays are "generated." These may be absorbed by placing filter paper, gauze or wood 1 centimeter or more in thickness about metal screens. In experimental work it is possible by means of the electromagnet to use the alpha and beta rays alone. Clinically, we can approximate this by varying the time of application and the thickness of the screens because of the relatively greater amount of alpha and beta than of gamma rays; the proportion is respectively 90, 9 and 1 per cent when no screens are used.

Injuries Incidental to Handling Radium.—The increasing use of large quantities of radium for therapeutic purposes makes it important to describe the symptoms and signs which may be caused by working with or even near radio active substances and to emphasize the importance of these as occupational injuries. Suggestions are offered so that more serious late effects may not result.

Rutherford states that Walkhoff first observed that radium rays produce burns of much the same character as those caused by Roentgen rays. Experiments in this direction have been made by Curie and Becquerel and others with very similar results. After handling radium there is at first a painful irritation, then inflammation sets in which lasts from ten to twenty days if suitable precautions are not taken. This effect is produced by all preparations of radium and appears to be due mainly to the alpha and soft beta rays. Care has to be taken therefore in handling radium on account of the painful inflammation set up by the rays. If a finger is held for some minutes at the base of a capsule containing a radium preparation, the skin becomes inflamed for about fifteen days and then peels off. The painful feeling does not disappear for two months.

Although these rather acute reactions due to radium are apparently well known to physicists working with radio active substances and considerable experimental work has been done on animals by biologists to show the histological changes produced, very little attention has been paid to the more chronic changes. With the increasing use of large quantities of radium, attention should be called especially to these changes to which those handling radium are subject. A proper realization of this fact is necessary, not only because of the annoyance and discomfort caused by the less serious effects of radium, but because with the analogy of the serious

lite effects of X ray burns in mind, a *warning should* be sounded against possible similar results from radium, such as atrophy, intractable ulcera

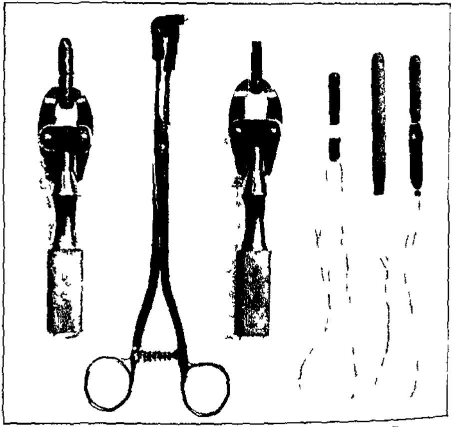
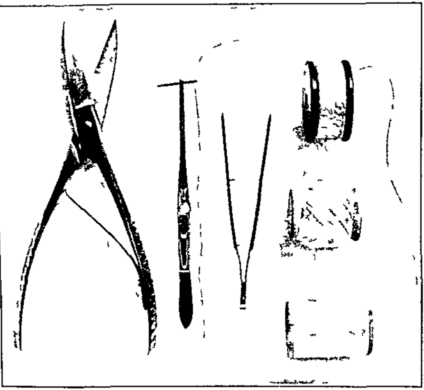


FIG 1—DEVICES FOR HOLDING BRASS CAPSULE TO AVOID CONTACT OF THE FINGERS. A watchmaker s vise filed out to grasp brass capsule in whi h non corrosive steel needles five to ten in number are placed B forceps grasping cover of bras cap sule These devices hold capsule and cover while screwing capsule open or clo ed thus avoiding injury to fingers by repeated contact C brass capsule held by strong silk In this are placeed five seven or ten needles containing 10 m of radium sulphate each D the capsule is then placed within rubber fountain pen reservoir for ke ping it clean and in certain instances to prevent soft secondary radiations from injuring the superficial tissue when a deeper effect is desired Such an applicator may be placed within the uterus held in place by packing for twelve to tw nty four hours depending on the nature of the condition treated and the amount of radium used

tion and even cancer Already in certain instances there has been caused not only great annoyance from discomfort but actual impairment in manual *dexterity* in performing delicate manipulations, because of persistent local anesthetic effects

The symptoms caused by handling radium may occur very insidiously and consist of blunting of sensibility of the finger tips, paresthesia such as increased sensitiveness to heat and pressure amounting at times to actual pain, and finally to anesthesia of varying degrees.



A B B C D E

FIG 2.—FURTHER DEVICES FOR AVOIDING CONTACT OF FINGERS WITH RADIUM A, shears found convenient for cutting sheet lead for use as screens and special applicators B, locking forceps to hold radium needle while it is being threaded with strong silk by holding end of silk in small forceps C, braided silk fish line, very strong and best for holding capsule D, spool of strong crochet silk for holding needles F, spool of ordinary surgical silk—not strong enough

The subjective disturbances are out of all proportion to the objective findings which include flattening of the natural ridges on the affected fingers with consequent changes in the characteristic markings of the finger prints, thickening of the horny layer of the epidermis with scaling in varying degree, failure of the tips of the fingers to resume their normal shape after pressure, a sort of pitting, upgrowth of the cuticle at the base of and underneath the nails which tend to stand off from the fleshy part

of the fingers and which become ridged easily cracked and extremely brittle

Various general symptoms such as headache, malaise, weakness undue fatigue, unusual need of sleep, increased excitability, fretfulness, irritability disorders of menstruation, attacks of dizziness, etc, have been said by Gudzent and Halberstaedter to be caused by repeated and long-continued exposure to radio-active substances Such symptoms are, however, common in many people at times and, as they cannot be accurately and objectively recorded, there is doubt if they can be definitely proved to be due to exposure to radium They may be due to close confinement, tiring routine and lack of outdoor exercise and other causes The exposures of some of the cases reported were doubtless large, some of the individuals affected were assistants in "Fabriks" for manufacture of radium apparatus and some had been engaged for years during the entire day in work with radio-active substances It is, therefore, probable that certain general symptoms do occur as a result of exposure

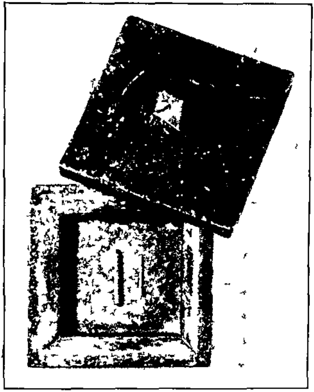


FIG 3—THICK SIDED LEAD BOX AND COVER TO PROTECT WORKERS FROM RADIUM RADIATIONS WHILE MAKING AND APPLYING APPLICATORS In the lead box are a non corrosive steel needle containing 10 milligrams of radium sulphate and a brass capsule in which are two similar radium needles

Changes in the blood of radium workers were observed by Gudzent and Halberstaedter Most striking was the relative and absolute increase in lymphocytes from 36 per cent to 63 per cent, average of ten cases 46 4 per cent, a relative and absolute decrease in neutrophils, average 50 3 per cent There was little change in red blood corpuscles slight diminution in white cells and the hemaglobin was lowered in only two cases, 70 per cent and 71 per cent respectively

Various methods have been devised for avoiding these injurious effects. In order that the least possible contact of the fingers with the radium may occur, forceps or special vises are used for holding tubes

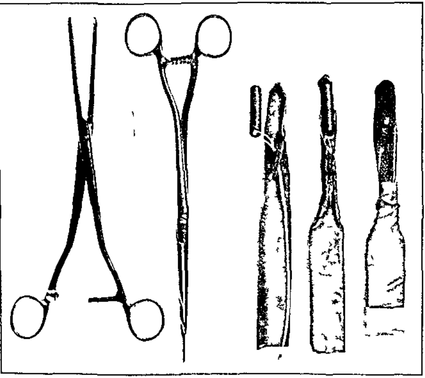


FIG 4.—DEVICES FOR PROTECTION AGAINST RADIOACTIVE SUBSTANCES. A, strong locking [illegible] holders used for grasping radium needles and [illegible] holder made to grasp [illegible] and thus facilitate their introduction into the tissues. B, steel holder [illegible] of 10 [illegible] to screen radiation and thus protect bladder or rectum [illegible] may be [illegible] applicator inserted into vagina or rectum respectively. The [illegible] applicator is covered with rubber finger cot and dental rubber sheet to keep it clean and to prevent secondary radiations [illegible]. The rubber [illegible] held in place by [illegible] adhesive plaster

and for opening and closing them. Special metal boxes have been constructed so that the active tubes may be safely stored and kept when not actually in use. Special rubber envelopes for containers have been devised in order to avoid wrapping the radium up by hand in sheet rubber (Fig 7). Leaded gloves, fingers, etc., are clumsy and are not readily worn

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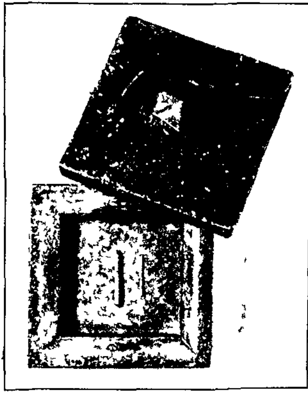

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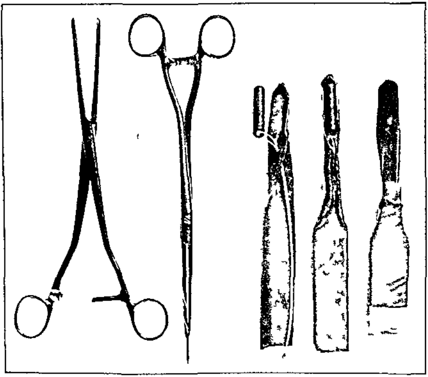

A B

FIG 4—DEVICES FOR PROTE TION AGAI ST RAIIC ACTIVE SUBSTANCE A t o g l ck ing needl h lders us l fo pin rad um ne ll anl f r ing t into gro tl Holler made t gra p radium re ll t variou gl s nd thu fa l tate the intr duct n into th ti i B l t l a l l h t l ll bra cap ule c ntaining f e to ten rad m neelles of 10 m l Tle l ad t to reen l at on anl thu protect bl lle r ti m a e m v b l n applicat s nsertel i to v a r ctum re pect ely Tl l arp d of tl l ad re filed mo th anl tle appl cator i cov rel ith ulber fin t and l tal rull r lc t n t k ep it lean and t pre nt e nl rv r liation f m lead Tl ubb r sh ti i held n plac b adhesive pla ter

and for opening and closing them pecial metal boxes have been constructed so that the active tubes may be safely stored and kept when not actually in use Special rubber envelopes for containers have been devised in order to avoid wrapping the radium up by hand in sheet rubber (Fig 7) Leaded gloves fingers etc are clumsy and are not readily worn

In placing active tubes in special applicators it is important to avoid all contact with radium and, as the effects are not apparent at once as when handling very hot objects such as heated glass, but only after a period of days or even weeks, it will be difficult to train a worker to avoid *all contact with the active apparatus*. Therefore, in the work of making routine applications of radium there should be a rotation in the staff and persons affected should be freed at least temporarily from such work.

In order to avoid general disturbances, the body should be protected as far as possible by metal screens in the form of lead boxes or plates about the radium, there should be frequent ventilation of workrooms, particularly if there is radium emanation present, and a change of duty and shorter hours, periodic physical examination of those working with radio-active substances with special reference to the blood examination is indicated.

From the above it is evident that marked changes may occur on the *fingers of those engaged in routine work with radio-active* substances. These local objective changes consist chiefly of flattening of the characteristic ridges, thickening and scaling of the superficial layers of the skin and even atrophy and intractable ulceration. These lesions are usually slight compared with the marked subjective symptoms, such as paresthesia, anesthesia of varying degree, tenderness, throbbing and even pain. The persistence of such effects is noteworthy.

Various general systemic symptoms and also blood changes may be produced by exposure to radio-active substances. To avoid such local and general disturbances special protective and preventive measures have been devised and those engaged in routine handling of radio-active substances are particularly cautioned.

Application and Administration of Radio-active Substances.—Radium may be used either externally or internally, for research or routine therapy. It may be used as a salt when spread evenly over applicators and retained in position by special varnish or the salt may be employed in tubes, needles or in special containers.

The emanation or radio-active gas evolved from a solution of radium has the properties of a gas, that is, diffusion, solubility in liquids, condensation, and liquefaction at a certain pressure and temperature. It is also radio active, that is, it ionizes air, discharges electrical bodies, affects photographic plates, passes through bodies opaque to light, and provokes phosphorescence in different substances and even in the glass which contains it. Emanation derived from a dilute solution of soluble salt of radium, usually the chlorid, may be freed from the admixture of hydrogen and oxygen, due to the hydrolysis of water, and reduced to a very small volume by Duane's method of passing it over a heated copper coil or by condensing the "impurity" of hydrogen and oxygen by liquid air. Then it may be passed by mercury pumps into capillary glass tubes which are

sealed off into lengths suitable for various containers The emanation may also be compressed into special containers and used without "purification" It may be set free into special chambers for inhalation or dissolved in water for drinking or for injection

Radium A, B, C, the so-called active deposit from the emanation, may be used for external application by various appliances or when deposited according to Duane's method it may be used medicinally by injection, etc. As radium in the form of a salt, such as the sulphate, loses half its strength in a little less than 2 000 years it may be regarded as practically constant for therapeutic purposes The emanation, however, loses half of its strength in 3 85 days that is, it weakens practically one sixth a day, therefore allowance for this must be made in treatment The deposited activity, radium A B, C loses half its strength in one hour Because of the technical procedures necessary for purifying the emanation and for obtaining the active deposit and because of the relatively short period of their activity, these forms of radium are in less general use except in clinics where a physical laboratory is maintained

The use of radium emanation however, has certain practical advantages, particularly in avoiding loss of the radium by theft or accident The solution of radium may be kept carefully locked in a safe while the emanation is constantly being formed from it The emanation may be put into containers of various sorts and conveniently sent away by post It should be borne in mind however that half the strength is lost in 3 85 days, therefore the emanation can be sent only a limited distance The disadvantages of using emanation are that it is constantly losing its radio activity as above indicated and it is, therefore somewhat more difficult to apply very exact dosage, which may be important in certain cases

Action of Radium Local and General—It has been said that radium acts merely as the most expensive and efficient form of cautery as yet discovered On the other hand, it has been claimed that the radiation from radium has a marked selective action in destroying pathological tissue without affecting normal tissue Between these extreme views however a mean should be taken While it is true that the alpha, beta and gamma rays do exert a somewhat selective action this however, is only relative, the more embryonic and cellular tissue being chiefly altered By prolonging the exposure however, even dense fibrous tissue may show changes There is great variation in the effect of radiation upon different growths and also on normal tissues The lymphatic organs are specially sensitive and easily destroyed and also the hair follicles the glands of the skin and the reproductive portions of the ovary and testis The endothelium of the blood vessels may swell up and cause occlusion of the vessels with marked diminution of the blood supply Cartilage bone muscle connective and nerve tissues including brain are very resistant to radiation

In many cases it is impossible to predict by histological examination which growths will be easily affected and which will prove refractory to the action of the rays Although it has been supposed that the action is purely local and direct upon the cells themselves, there may also be an indirect, possibly cytolytic, or other "immunity" reaction secondarily produced The destruction of tissues exposed to radium is usually by necrobiosis, the nuclei become swollen and vaculated, the nucleoli become enlarged and fragmented, the staining characteristics of the tissues are altered, and death of the cell ensues It is believed that the effect of the radiations [3] is to produce ionization of the atoms of the different substances the rays penetrate and that chemical changes follow as a secondary result of the ionization

After exposure to radio-active substances there is usually a latent period of longer or shorter duration before the effects become evident. This latent period varies from one or two days to even two or three weeks *or longer It depends in most instances upon the strength* of the source of energy and upon the amount of filtration and protection used In certain instances it may depend upon personal idiosyncrasy

The effects of exposure to radio active substances may be either local or general Local effects on the skin may vary in intensity from erythema to vesiculation or ulceration of varying degree and possibly lead to the development of cancer To these dangers the attention of those engaged in radium therapy is particularly called General effects such as sterility, changes in the blood, and constitutional disturbances such as nausea and vomiting may occur [4]

Comparison of X ray and Radium—Although there are numerous physical differences between Roentgen rays and those emitted by radio-active substances, in certain respects they are analogous They produce similar chemical action on photographic paper or film, they cause fluorescence, they penetrate opaque objects, and have the property of ionizing the air and so rendering it a conductor of electricity The similarity between the physiological action of the Roentgen rays and of radio active substances, particularly if used by like methods, is striking In general it may be said that the local therapeutic effects of unfiltered X rays produced by soft tubes and low voltage may be compared with rays from radio active substances if filtered through a very thin sheet of paper or aluminum which intercepts merely the alpha rays, that is, unscreened rays with very short exposures of a few minutes are comparable in effect to weak beta rays of radio-active substances with exposure of from fifteen

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[3] Radiations will be the term applied to rays particles or electrons derived from radio active substances

[4] These have been described in considerable detail by Tyzzer and Ordway in Diseases of Occupation and Vocational Hygiene Kober and Hanson P Blakiston's Son & Co 1916

minutes to an hour Such rays have comparatively little penetration and are used in the treatment of superficial lesions of the skin and mucous membranes for it is believed that only the rays absorbed produce physiological changes It is, therefore necessary in order to produce any marked effect on deeper tissues to use screens or filters to check the less penetrating rays which would otherwise be absorbed by the superficial tissues and cause marked destructive changes there, before the less numerous and more penetrating rays could act on the deeper tissues When using radium it has been shown that screens or filters (lead 2 or 3 millimeters thick, brass 1 2 millimeters, or other heavy metals such as silver and gold or platinum) allow the penetrating hard beta and gamma rays to pass and intercept the alpha and soft beta rays which would otherwise be absorbed and cause destructive changes in the superficial tissue It must be remembered in this connection that metals more particularly lead used as filters for radiations do give off, in a varying degree soft beta the so called secondary rays As the amount of the more penetrating rays is only a small proportion of the total activity, less than 5 per cent it is necessary in deep therapy to make the exposures correspondingly long Hours are required even twenty four, forty eight or longer, for deep therapy with heavily screened apparatus, whereas a few minutes to an hour are used in the treatment of more superficial lesions with radium Fluorescent dyes, colloidal metals and other substances have been advocated to activate or intensify the action of radiations They have not as yet, however been proved to be of clinical value

In practical radium therapy radio active substances are in certain cases doubtless preferable to the use of Roentgen rays particularly when there is necessity for the most precise localization especially within the body or in the cavities difficult of access al o when the condition of the patient or circumstances demand portability of the therapeutic agent for convenience or ease of treatment The disadvantages of radium are its great expense for sufficient doses necessary in some cases also the possibility of loss of the salt by accident or theft This may however be obviated by insurance of the radium or by use of the emanation as above indicated but the expense of the latter is increased because of the necessity of retaining a physicist and equipping and carrying on a physical laboratory When sufficient clinical experience has been gained in the application of the recent advances in the production of highly penetrating homogeneous X rays of great volume by Coolidge and his coworkers, supplemented by careful scientific study of the physiological effects, we believe that there will be in the majority of cases very little difference in the therapeutic value of the X ray and radio-active substances

If radium is to be employed as a therapeutic agent it is important not to use X ray or any form of caustic previously, for the results of radium therapy under such circumstances are usually very disappointing

Medicinal Use of Radium.—The treatment of so-called medical diseases by radio-active substances must be considered even at the present time to be in the experimental stage. The indications and contra-indications are not as yet clear nor have the results been sufficiently definite in many instances of supposed cure to judge the real value of the treatment.

Radium may be administered internally as a therapeutic agent by various methods. A *soluble salt* such as the chlorid or bromid of radium may be injected into the body or taken by mouth or used for bathing. The *emanation*, the radio-active gas evolved from a solution of radium, is somewhat soluble in water and may thus be used in the same manner as the soluble salt. In the form of gas it may also be taken into the lungs by various devices—in the small personal respirators, with mouth or nose pieces, in cabinets or in bed or in room emanatoria. Patients remain for hours in some of these, the resulting carbon dioxid and water vapor are removed by soda lime and sulphuric acid, oxygen is added, and the temperature is controlled by coils as in the calorimeter. The *active deposit* radium A, B, C, when deposited on salt, may be administered in a manner similar to the soluble salt above indicated. The dosage of the various forms of radium taken internally is, at present, very variable, wide range having been employed by various workers as below indicated.

Radio-active substances may be employed in other ways. In the form of packs, naturally active material of pitchblende residue or artificially activated material is used. It has also been given as baths, the water being derived from naturally radio-active springs or water to which has been added soluble radium salt or emanation. Indeed, it has been claimed that the beneficial effects of the waters of certain well known springs are due to the fact that they contain radio-active substances, chiefly emanation. When radium or its products are given by mouth, it is believed by von Noorden that there is greater effect upon the liver, as the emanation reaches the heart through the portal veins and leaves the body almost entirely through the lungs within a few hours. When emanation is inhaled he considers that the emanation goes more rapidly into the general circulation. In the radio-active bath of 200 liters the natural radium content varies from 31,000 to 120,000 M. E. (Mache units) or in some instances *450,000 M. E.*[5]

When water is artificially activated, similar amounts have been used. When radium emanation is used for drinking, 1,000 M. E. a day up to 10,000 or, in certain instances, 90,000 M. E. a day have been given by the German school. They usually begin with doses of 330 M. E. three times a day and for further treatment proceed to 5,000 or 10,000 M. E. three times a day and in individual cases 30,000 to 90,000 M. E. a day. The Radium Institute in London, during the year 1914, recommended the

[5] One thousandth of a milligram (a microgram) of radium solution in equilibrium is equivalent to 2,700 M. E. of emanation.

drinking of at least 1/4 liter of water activated by emanation containing at least 1 millicurie per liter (a millicurie being equivalent according to the physicist at this Institute to 2 160 000 M E) This would make the dosage vary from 540 000 to 1 080 000 M E daily It is believed at the Radium Institute that at least six weeks treatment is necessary before benefit is noticed

When a solution of the soluble salt of radium is used for drinking or for subcutaneous injection the dosage given has varied from 50 to 250 micrograms The above indicates the very great variations in the dosage which have been employed by different observers Similar variation is seen in the case of emanatorium treatment in which some recommend per liter of air 2 to 4 M E, others begin with the same dose and increase to 22 M E and gradually to 45 in special cases to 110 eventually to 220 440 or even 660 M E Von Noorden and Falta have given 1 200 M E per liter Coutard recommends emanation from 2 to 4 milligrams of bromid of radium (without accumulation) in a room of 10 cubic meters He has the patient remain in this room for one and one-half hours Various devices are now on the market for furnishing water containing emanation The dose is in many instances small and it is important that the products of apparatus used in conjunction with radium therapy should be carefully analyzed by a competent physicist for the true radium content

Physiological Action of Emanation—It has been claimed that emanation in many patients increases the gaseous exchange and the respiratory quotient In Basedow s disease although the basal exchange is above normal, it may be still further increased by emanation Emanation is thought by some to increase sugar metabolism as well as that of albumin and purins The uric acid output is particularly increased by emanation in cases of gout The influence of emanation on the blood picture may be striking at first there may be hyperleukocytosis and later a diminution in white cells There is a relative increase in mononuclear cells It is also claimed that in certain instances emanation acts as a diuretic and it has been said to exert a stimulating influence on the sex glands particularly in cases of acquired impotence or in tabetics or in senility Cases are cited of the return of menstruation after the menopause and also in certain instances of amenorrhea It has also been asserted that radio active matter modifies the phenomena of inflammation and stimulates the action of the various ferments—such as the pancreatic, peptic, and lactic acid and the autolytic ferments in the tissues

Attention has been called to such symptoms as dizziness pressure in the head weakness albuminuria and hemorrhages following large doses and experimentally it has been found that serious complications may result in animals With large doses also there may be marked changes in the metabolism and in the blood picture Such claims have not been

Medicinal Use of Radium.—The treatment of so-called medical diseases by radio active substances must be considered even at the present time to be in the experimental stage The indications and contra indications are not as yet clear nor have the results been sufficiently definite in many instances of supposed cure to judge the real value of the treatment.

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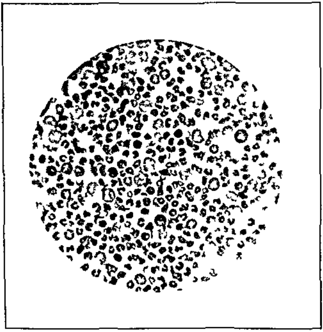
Gonorrheal Arthritis —The results are not favorable although occasionally improvement is obtained on injecting solutions of soluble radium salt in the vicinity of the joints

Tuberculosis of Joints —Results are not favorable

Gout —His reports a large series of cases of gout treated by emanation, the uric acid content of the blood is said to be greatly lessened although there is not a complete parallel in the blood content and the



A

Fig 54 —A Blood Smear from a Patient with Myelogenous Leukemia Taken *before* Radium Treatment White blood count 500 000 large number of myelocyte and myeloblasts are seen

clinical changes Some cases show improvement in the general condition subsidence of joint swelling without marked diminution of uric acid in the blood Other cases with gouty nodes, even in periods of the most frequent attacks *show no abnormal amount of uric acid in the blood* Many cases under treatment by radium emanation show disappearance of the tophi in the ear Gudzent reported one hundred cases of gout in some of which he secured still further improvement by injection of a dilute solution of radium salt In the beginning of treatment there may be temporarily an increase in pain as the result of reaction Emanation may be used both by drinking and by inhalation Radium should not replace

generally confirmed It should be realized that the real value of the internal or medicinal use of radium and its products is at present doubtful, and because of the possibility of harmful effects it is advisable to begin with small doses and to be conservative in our estimation of the results

THERAPEUTIC EFFECTS OF RADIO ACTIVE SUBSTANCES

Arthritis Deformans (*Chronic Rheumatism*) —The types with exudation are said to be more favorable than the dry forms His has reported cases with striking improvement in the general condition At the Radium Institute in London, Pinch reports extremely favorable results sometimes, as he said the results are remarkable At this Institute, 250 c c of emanation solution of a strength not less than 1 millicurie per liter up to 2 millicuries per liter are given to patients suffering from this obstinate, painful, and crippling disease Pinch says that it is difficult to predict with certainty the degree of improvement likely to occur in any particular case but that the cases which appear to derive most benefit are those in which the disease is of relatively short duration and the changes are periarticular in type and multi articular in distribution The age of the patient also exerts some influence, those under forty responding more quickly to the action of emanation Little or no improvement can be looked for in instances when cartilaginous or osseous changes are predominant When limitation is due to periarticular fibrous thickening considerable increase of mobility often follows and enables patients to perform actions such as feeding themselves, brushing their hair, shaving, etc, which they may have been powerless to do for some months or even years Muscular and articular pains are lessened or disappear, grating of the joints on movement is not so marked, muscles may regain much of their lost tone, and the patient's general health may be much improved The treatment must, however, be persisted in for quite a long time, at least six weeks before any change is noted McCrudden believes that the creatinin metabolism may be influenced by radium emanation water

Acute Articular Rheumatism—In the majority of cases treated by von Noorden it is claimed that emanatorium treatment acts as well as salicylates, the local symptoms subsiding in a few days Salicylates were used in conjunction with emanation, however, in certain case The treatment was from two hours to over night and the doses 220 to 1,200 M E Von Noorden and Falta believe emanation is specially valuable in cases which do not stand salicylates well

Chronic Arthritis—In arthritis secondary to acute general infections or from a focus in the tonsils, teeth, etc, results are doubtful

Gonorrheal Arthritis—The results are not favorable although occasionally improvement is obtained on injecting solutions of soluble radium salt in the vicinity of the joints

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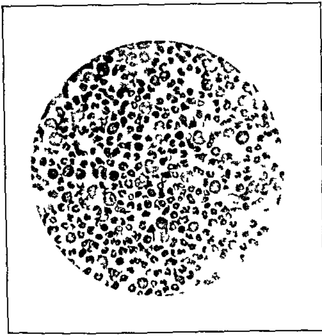


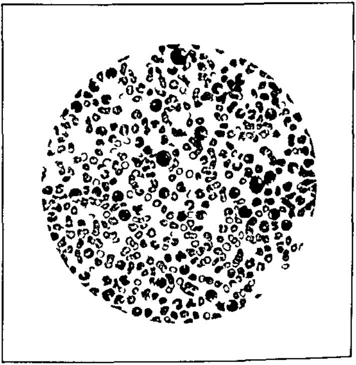
A

FIG 54—A BLOOD SMEAR FROM A PATIENT WITH MYELOGENOUS LEUKEMIA TAKEN *before* RADIUM TREATMENT White blood count 500 000 large number of myelocytes and myeloblasts are shown

clinical changes Some cases show improvement in the general condition subsidence of joint swelling without marked diminution of uric acid in the blood Other cases with gouty nodes even in periods of the most frequent attacks show no abnormal amount of uric acid in the blood Many cases under treatment by radium emanation show disappearance of the tophi in the ear Gudzent reported one hundred cases of gout in some of which he secured still further improvement by injection of a dilute solution of radium salt In the beginning of treatment there may be temporarily an increase in pain as the result of reaction Emanation may be used both by drinking and by inhalation Radium should not replace

treatment by diet and other common aids in the treatment of gout such as hygienic measures, colchicum and related drugs.

Leukemia.—Von Noorden and Falta did not obtain any favorable results by emanatorium treatment in leukemia but only produced an increase in the blood count. The writers, however, by surface applications of radium over the enlarged spleen have, in a series of cases, observed a most remarkable improvement and striking changes in the size

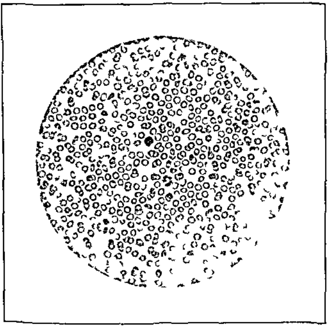


B

FIG. 58.—A BLOOD SMEAR FROM A PATIENT WITH MYELOGENOUS LEUKEMIA TAKEN *during* THE COURSE OF RADIUM TREATMENT. There is a marked diminution in the number of white blood-cells (74,000); the diminution is chiefly in the myeloblasts and myelocytes with a relative increase in the polymorphonuclear leukocytes.

of the spleen, the blood picture, and the general condition of the patient. In the course of a few weeks or, in stubborn cases, in three or four months after treatment by the surface application of radium according to the method described in this article, a spleen which filled almost the entire abdomen, extending well to the right of the median line and into the pelvis and causing marked pressure symptoms, has been reduced to normal dimensions so that it was not palpable below the costal margin. Blood with white counts of from 500,000 to 700,000 became 6,000 to 8,000. The immature forms of white cells—the myeloblasts, myelocytes—are es

pecially affected The hemoglobin increased from 40 to 70 or even to 80 or 90 per cent The red blood-corpuscles increased from 2,000,000 and 2,500,000 to 4,000 000 and 5 000 000 indeed the blood picture often approximated normal A pale emaciated anxious individual with prominent bony framework stooping shoulders and enormously enlarged abdomen usually loses the anxious expression becomes plump the abdomen returns to normal size the color and strength improves so that the patient



C

FIG 5C—A BLOOD SMEAR FROM A PATIENT WITH MYELOGENOUS LEUKEMIA TAKEN *aft* THE COURSE OF RADIUM TREATMENT The myelocytes have entireely disappeared the white count is 800 considerable variation in size and shape of the red cells persist however

may feel entirely well The pathological condition however sooner or later is apt to relapse gradually and the response is less prompt in subsequent series of radium treatments although cases have been kept in good condition for a period of one to four years by occasionally repeating the radium treatment. Numerous cases however have died of intercurrent infections or have succumbed *to the original disease Although these results* in the radium treatment of leukemia are most striking in the chronic myelogenous variety in certain cases of lymphatic leukemia results are almost equally good It must be understood however that the results should be regarded at the present time merely in the light of palliation and not as cures.

It is hoped, however, that future research will at least increase the duration of these remissions Although the treatment must not be considered at the present time as curative, from the results obtained it is the best form of treatment now at our disposal Certain of the cases which respond promptly to radium applications over the spleen had previously proved entirely refractory to prolonged X ray and to benzol treatment

It is to be noted, however, that in the surface applications of radium above described the results were obtained without radiating the long bones, in fact, in one instance in which the long bones were radiated there was apparently, an increase rather than a diminution in the white cells It is also believed that the results are more prompt by the radium treatment than by X ray as hitherto employed, and no case has been accompanied by severe toxic symptoms, although there is a marked increase in the endogenous purin metabolism On a purin free diet, uric acid, urea and total nitrogen in the urine are markedly increased

Miscellaneous Conditions—In a few cases of croupous *pneumonia* it is claimed that the temperature began to fall earlier than usual and by lysis and that the dissolution of the exudate was strikingly rapid The symptoms, such as difficulty in breathing were markedly relieved in the emanatorium in which 100 M L of emanation per liter was used In certain instances the patients remained in the emanatorium over night In *diabetes mellitus* the effect upon the sugar metabolism is not constant but the emanation therapy is said to affect favorably diabetic neuritis In certain cases of *neuralgia* neuritis, and sciatica, it has been claimed that the condition has been benefited Claims have also been made for favorable therapeutic effects in the case of *arteriosclerosis* certain kidney diseases and even in tabes dorsalis, in the latter instance more particularly in relieving the so-called lightning pains In some cases of *syphilis* in which a positive Wassermann persisted in spite of active and prolonged treatment intravenous injection of from fifty to two hundred and fifty micrograms of radium chlorid solution at intervals of a few days and later once a week resulted in the reaction becoming negative in certain instances It would seem, however, that there has been much exaggeration of the value of radium in many of these chronic conditions

The indications and contra indications for the internal use of radium are vague The value of the medical uses of radium has been greatly exaggerated and reports are confusing The great variations in dosage add to this There seems no question, however that benefit has been derived in certain forms of gout and chronic rheumatism and neuritis The effect upon the hematopoietic tissues, whether stimulative or destructive, must, however, be borne in mind Improvement has also been reported in cases of pernicious anemia erythrocythemia and in hypertension In the latter the blood pressure is said to have been reduced to normal and the subjective symptoms are said to have disappeared

Internal therapy by radio-active substances is still too recent and poorly controlled to express a very decisive opinion regarding its value The duration of favorable results reported is not known in most instances There is need of more control cases and of a large number of cases worked up in detail treated by different methods and followed to end results before certain conclusions may be drawn.

External and Surgical Use of Radium —The value of the so-called surgical use of radium is much more definitely established than its medicinal use Even the most conservative and careful clinicians who have had any extended personal experience with adequate amounts of radium recognize its value and limitations when used in certain surgical diseases In a large proportion of this class of cases, surgery is undoubtedly preferable and radiations if employed at all should be used not to replace but, in many instances, to supplement surgical procedures We believe that many of the extraordinary claims have prevented a proper estimation of the true value of radium therapy, both by the profession and the laity This has been due to the fact that the exceptional cases in which there has been great relief or even cure have been reported as if they were the rule In describing the limitations of radium therapy the fact must be taken into account that there are from time to time very exceptional cases particularly of malignant tumors some of which have repeatedly recurred after numerous operations and also cases that have been entirely inoperable which have apparently yielded to radium therapy While the careless or the overenthusiastic physician has described these cases as if they were the rule yet it is by studying them most carefully and becoming acquainted with as many of the factors involved as possible that we may hope that these now exceptional and unusual cases may become more and more frequent It is thus also that we may expect truly to advance the progress of radium therapy In describing conditions in which radium therapy has been used it is difficult to follow a systematic or logical arrangement either from the point of view of pathology, etiology or anatomy Therefore both anatomical and pathological arrangement will be made use of

Methods of Application —It is almost impossible to give detailed rules for the application of radiations The source of radiation for therapeutic use should be not only physically but physiologically standardized under the exact conditions in which it is to be employed The duration, amount of radio active element filtration distance and in certain instances the individual variation of the subject of the experiment must be considered The great variation in the reaction of different tumors to the radiation has been pointed out by Werner In practice it has been found of the utmost importance to use the method of physiological standardization not only for becoming familiar with the various changes produced in animals but in the tissues of man subjected to radiations For example

in order to apply radium intelligently for therapeutic purposes, it is necessary to establish a so called "erythema dose," that is to determine the tolerance of the skin to the various radiations under the conditions employed

The degree of the acute reaction following the exposure is very variable depending upon several factors, namely, the intensity and quality of the radiation, the duration of the exposure, the part of the body exposed, and the individual sensitiveness or tolerance Gocht claims that there is no special idiosyncrasy as was at one time believed The intensity and quality of the rays depend on the amount of radio active substance, the distance it is from the patient and the filtration employed The effects depend on the rays absorbed by the tissue The therapeutic indications and effects of the X rays and radio-active substances are almost identical when employed by similar methods

Numerous refinements of the technic of radium application have been suggested, and while some of these may facilitate the more exact fixation of the radium to the area under treatment, just as good results may be obtained by simpler applicators, if due care is taken. For the treatment of lesions about the face or mouth, molds of dental wax may be made in which the radium is embedded In some clinics where emanations are used, capillary glass tubes or "seeds" containing minute quantities of this form of radium are buried in the diseased tissue and left there Since the introduction of needles containing radium element however the same results may be obtained by inserting the metal needle and withdrawing it by a thread attached to the eye of the needle, after the desired length of exposure

Unusual technical methods such as having the radium rotated by a clocklike mechanism so as to diffuse the rays, on the theory of more even distribution, do not seem to offer any practical advantage in treatment

The strength of radium depends upon the amount of radium element present Therefore, in reporting cases the dosage should be accurately stated in milligrams of radium or millicuries of radium emanation per hour, per unit area A millicurie is the quantity of emanation that furnishes the same penetrating radiation that 1 milligram of radium element produces The dose employed in the external and the so called surgical use of radium usually varies from 50 to 200 milligrams, in certain instances 1 or 2 grams have been used The smaller doses are employed chiefly in superficial skin lesions, the larger for large growths deeply situated

Tubes, needles, and surface applicators containing radium are used on patients according to the following general rules to which, however there are many exceptions These rules indicate only single applications and can give no idea of the total number of applications or of the time elapsing between them The number of applications varies greatly with

the variety and size and extent of the lesion and the intervals are, in most instances, from four to six weeks although, in certain cases applications are made every day or two for a week and then, if necessary repeated at the regular four to six weeks interval The most obvious improvement usually occurs after the first or second application which should, therefore, be of sufficient intensity to produce the best results Repeated ineffectual applications at too frequent intervals may produce actually harmful destructive effects Small superficial lesions may require only a single application of a half hour to one hour's duration The time of application depends not only on the strength of the applicators as above indicated but also on the size and nature of the lesion the area to be covered and the sensitiveness of the patient's skin Certain technical details of application are illustrated in the accompanying illustrations (Figs 1, 2, 4 6 and 7)

GENERAL RULES FOR APPLICATION OF RADIUM

(The following rules apply when an average of one hundred milligrams of radium element or its equivalent emanation are used)

1 **Effects on Pathological Processes Beneath Intact Skin** —Surface application—*screening* or filtration 2 to 3 millimeters of lead or equivalent, *protection* from secondary radiations gauze or paper, wood, distance, and rubber, *exposure* four to six hours or less

2 **Superficial Skin Lesions** —Such as keratoses small growths etc *Screening* none or 0 1 to 0 5 millimeters of aluminum or lead, *protection against secondary radiation* none or rubber cover to keep applicator clean adjacent normal skin carefully protected by a shield of 1 to 2 millimeters of lead gauze and rubber *exposure* ten minutes to two hours

3 **Deep Skin Lesions with Ulceration** —*Screening* none or rubber cover for keeping applicator clean *protection* of adjacent tissue as in No 2 *exposure* two to four hours Note if lesion is extremely deep or very extensive *screening* 1 to 3 millimeters of brass or lead and rubber *exposure* four to twelve hours or even longer

4 **Lesions of Mucous Membranes when Superficial** —Same as No 2 except exposure of one to two hours

5 **Lesions of Mucous Membranes when Deep and Growths Beneath Mucous Membrane** —Same as No 3 except exposure twelve to twenty four and forty-eight hours duration and in exceptional instances somewhat longer

6 **Introduction of Radium within Growths** —(*a*) For deep effect tubes with screening of 1/2 to 1 millimeter of silver or platinum Exposure four to forty eight hours depending upon size and nature of tumor average, twelve to twenty four hours (*b*) For local destructive effect,

in order to apply radium intelligently for therapeutic purposes, it is necessary *to establish a so-called "erythema dose," that is*, to determine the tolerance of the skin to the various radiations under the conditions employed

The degree of the acute reaction following the exposure is very variable depending upon several factors, namely, the intensity and quality of the radiation, the duration of the exposure, the part of the body exposed, and the individual sensitiveness or tolerance Gocht claims that there is no special idiosyncrasy as was at one time believed The intensity and quality of the rays depend on the amount of radio active substance, the distance it is from the patient and the filtration employed The effects depend on the rays absorbed by the tissue The therapeutic indications and effects of the X rays and radio-active substances are almost identical when employed by similar methods

Numerous refinements of the technic of radium application have been suggested, and while some of these may facilitate the more exact fixation of the radium to the area under treatment, just as good results may be obtained by simpler applicators, if due care is taken For the treatment of lesions about the face or mouth, molds of dental wax may be made in which the radium is embedded In some clinics where emanations are used, capillary glass tubes or "seeds" containing minute quantities of this form of radium are buried in the diseased tissue and left there Since the introduction of needles containing radium element, however, the same results may be obtained by inserting the metal needle and withdrawing it by a thread attached to the eye of the needle, after the desired length of exposure

Unusual technical methods such as having the radium rotated by a clocklike mechanism so as to diffuse the rays, on the theory of more even distribution, do not seem to offer any practical advantage in treatment

The strength of radium depends upon the amount of radium element present Therefore, in reporting cases the dosage should be accurately stated in milligrams of radium or millicuries of radium emanation per hour per unit area A millicurie is the quantity of emanation that furnishes the same penetrating radiation that 1 milligram of radium element produces The dose employed in the external and the so-called surgical use of radium usually varies from 50 to 200 milligrams, in certain instances 1 or 2 grams have been used The smaller doses are employed chiefly in superficial skin lesions, the larger for large growths deeply situated

Tubes needles, and surface applicators containing radium are used on patients according to the following general rules, to which however there are many exceptions These rules indicate only single applications and can give no idea of the total number of applications or of the time elapsing between them The number of applications varies greatly with

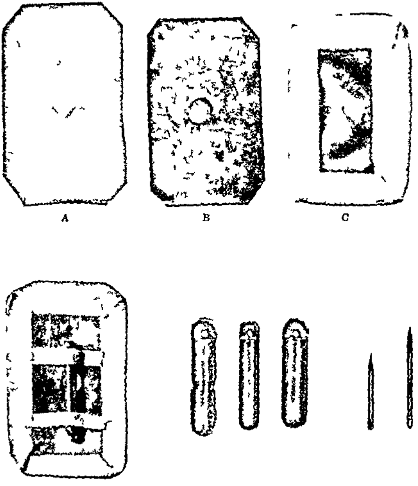


FIG 8.—EQUIPMENT FOR TREATING SMALL SUPERFICIAL LESIONS OF THE SKIN. A, piece of rubber m to cycle inn r t le to b fa t ned to nit t prevent on lary soft beta radiation f n l al protecting reen which protect l lthy kin adjacent to small l on B l al protecting r n l, o m n h tl ck Hol it in th s is l tly smaller than l on t be treated C, rubber held to l ad l v all size plaster th t al protect e l ad h ld D brass capsule containing radium needles h ld over penin in protecting h ld Usually for such an application in superficial l ns radium needles ar u d in tead of brass capsules E brass capsules f different sizes to c nt varying number of radium needles F non corrosive steel needles containing 8 to 10 mg of radium sulphate usually 10 mg

unfiltered tubes, one to two hours up to twelve hours, length of time depending upon size of growth and reaction desired. Unfiltered needles (10 milligrams each), *exposure for three hours usually* causes necrosis without liquefaction and is a most useful method when the needles are evenly placed. Capillary glass tubes containing 2 millicuries of emanation, inserted into the pathological tissues by means of a trochar, are *allowed to remain, the emanation undergoing slow decay and the glass* tubes becoming encapsulated by fibrous tissue.

Further Details of Application.—For deep effects when 2 to 3 millimeters of lead or equivalent are used for filtration, the skin, if intact, is protected from the action of the secondary, less penetrating rays by fifteen to twenty layers of gauze, paper, or by distance. In practice, radium applicators are wrapped in a thin sheet of rubber to prevent soiling, the rubber containers being changed with each patient. In order to fasten the radium in place and to secure exact apposition which is so necessary for successful results, double-coated adhesive plaster, such as is used in the Wickham and Degrais clinic in Paris, has recently been advocated by Tousey and is of great technical aid in radium therapy. Supporting bandages, especially of the four-tail variety, are useful in relieving the tension on adhesive plaster and holding the radium pack in place. Satisfactory sterilization of tubes and needles is secured by soaking them in full strength lysol or carbolic acid, then washing them off in alcohol and putting *them in boric* acid solution until used. For cleansing Clissold recommends soaking the tubes and needles in equal parts of ammonia and peroxid; this quickly removes the dried blood or the dull appearance, then transferring to alcohol and to ether, which rapidly dries the tubes *and needles before they* are put away. We have found this method of great assistance.

Protection.—In treating superficial lesions, particularly small lesions of the skin, by radium, it is necessary to use a sheet or mask of lead 1 *millimeter or more in thickness, with gauze or paper beneath it,* or a coating of rubber with a hole cut in the shield slightly smaller than the lesion to be treated. A harness or card punch is more convenient than a knife for cutting the opening in the sheet lead. Through the opening the lesion *may now be exposed to radium and the adjacent* healthy skin thus protected.

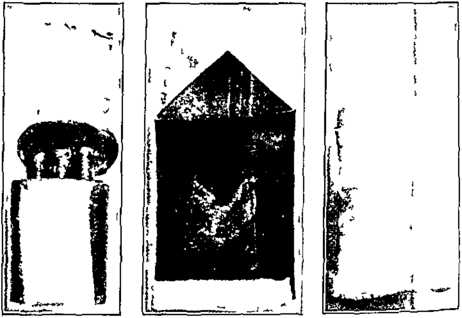
Cross fire.—The principle of the so-called 'cross fire' is important for successful application of radium to large growths or to deep-seated *lesions.* The *method was first described by* Dominici and has since been elaborated by others, notably in the treatment of uterine fibroids by X-rays in the Freiburg clinic. The aim is to concentrate as much of the action of the rays as possible in the deep-seated lesion, with the least possible injury to the overlying skin. This may be accomplished by employing small tubes of radium scattered throughout the tumor mass or by surface

a skin pencil or grease paint the outline being indicated by percussion and palpation Then the various landmarks such as the costal margins, anterior superior spine of the ilium the symphysis pubis and the umbilicus are also marked The patient is photographed in an erect position in both frontal and lateral views A series of small squares about 3 centimeters in diameter when the radium applicator is 2 centimeters in diameter, are marked over the area of enlarged spleen It is important not to have the successive application areas too near together or the skin between will be burned by the double dose The squares are numbered serially Tracings are now made on tracing cloth which serves as a chart for guidance in following the series of treatments A swathe of thin cotton is carefully fitted to the abdomen and the outline of the enlarged spleen bony landmarks and small squares is traced upon it This swathe is left in place during the single series of treatments The purpose of the swathe is to avoid the irritation of repeatedly applying and removing the adhesive plaster which holds the radium applicator in place It has been found that the area which is being or has been radiated is particularly sensitive to injury from the repeated application and removing of adhesive plaster The added irritation may induce vesiculation or even superficial ulceration of the skin

With the chart as a guide the radium applicator screened with 2 to 3 millimeters of lead or brass and fifteen to twenty thicknesses of filter paper and wrapped in gauze is now applied to the squares in the order indicated It is necessary also to add at least as much filtration and protection to the external side of the applicator for the patient may inadvertently bring some other part of the body in contact with the applicator during sleep and serious burns may result In the second series of treatments which is usually necessary in four to six weeks applicators are similarly applied A new swathe and tracing should be made at each series The duration of the application in each area with 50 to 100 milligrams of radium is four to six hours An amount of radium as small as 25 milligrams has reduced a greatly enlarged spleen to normal size and caused the characteristic improvement in the blood and general condition of the patient but the time required is longer and the applications must be more numerous

The importance of the distance of the radium from the skin is well shown in the illustration of Burnam He compares a tube 1 millimeter away from the ...atoses and ...o have be... one minute with the same tube 1 inch away that ...ation of r... In some ... h would require 25 times 25 or 625 minutes to produ... ...ect By increasing the distance however the difference in intensity becomes less for parts below the surface of the skin but it would be necessary to increase greatly the duration of application as above indicated or the amount of radium if radiation at a distance were employed for filtration

applications of heavily screened radium to a large number of areas on the skin so that each area will not be exposed too long or too intensely, a result which would follow the application of the radium to a single area for the time necessary to produce the desired result on the underlying lesion. By this cross fire method enormous doses may be applied to the deep lesion.



A B C

FIG. 7.—APPLICATOR FOR TREATING DEEP-SEATED LESION BY SURFACE APPLICATION THROUGH THE SKIN WHEN THE LATTER IS INTACT AND DEEP BUT NOT SURFACE EFFECT IS DESIRED. A, three brass capsules containing respectively four, two and four radium needles in a lead box $\frac{7}{16}$ or $\frac{3}{16}$ inches thick. B, the latter is slipped into an envelop made of the inner tube of a motor cycle tire. The cover of this lead box and the flap of the rubber envelop are held by adhesive plaster. C, gauze bandage is folded into twenty or thirty layers and placed over the applicator for comfort of the patient and to aid in avoiding injury to the skin from secondary radiations from the lead. This effect may also be secured by filtration by distance by means of a woolen block, but gauze and felt, etc., are more comfortable.

Deep Therapy.—Cross fire as above described, in order to be successful on deep-seated lesions beneath the skin, requires strong filtration of the rays. The technic of the so-called deep therapy, which should be used when the greatest effect is desired on deep-lying disease processes, may be illustrated by the striking result of radium when applied in the proper manner to the surface over the enlarged spleen in cases of myelogenous leukemia. For this the following details have been elaborated. The area of the enlarged spleen is carefully and plainly marked out with

or other forms of operation are attempted to close the wound deep recurrences are thus obscured and cannot be treated in time The superficial lesions treated by radium require from one-half to a few hours exposure, while the deep lesions require twelve or eighteen hours or more When the ulcers affect mucous membranes the results are less favorable

Epitheliomata.—In some epitheliomata of the skin the results of radium therapy are curative In the fleshy (basal cell) type of carcinoma called by the French 'carcinome bourgeonnant the results are remarkable Large growths melt away under the influence of radiations The success of this treatment depends largely on the careful and frequent cleansing of the lesion between the series of treatments

FIG 9.—PATIENT IN FIG 8 AFTER RADIUM TREATMENT (From Simpson C V Mosby Co)

Epidermoid Carcinomata.—As these growths are apt to metastasize early it is unwise to attempt their treatment by radiation There should be prompt and complete excision unless the location or stage of the disease contraindicates. In cases which are inoperable because of their extent or in those which have recurred after operation the results are rarely if ever curative although occasionally radiation may be of palliative value

Roentgen Ray Lesions.—Roentgen ray lesions of the skin, such as fissures keratoses and early epithelioma, are cured or greatly benefited by the application of radium Deeper lesions however, demand excision or amputation

Papillomata Verrucæ and Keratoses.—When keratoses are present the results are much more rapid if the heaped up horny material is removed by salicylic acid 10 to 20 per cent in flexible collodion The acid is thus held circumscribed and may be left in place for twenty four hours.

For deep therapy in the natural orifices and cavities of the body, radium applicators are protected by rubber covering in order to prevent the more local effect of the secondary rays as well as for keeping the applicators clean Such treatment may be applied at one sitting or intermittently within a few days There should then be an interval of from four to six weeks during which the patient should be observed and the radiated area cared for by surgical cleanliness It should be noted that as a rule the maximum beneficial effect is obtained with the first treatment, which should be the theoretical optimum dosage

External Use of Radio-active Substances

Diseases of the Skin —In the field of dermatology radium therapy has been most extensively used and is a most important therapeutic agent

Fig 8 —Epithelioma of Right Ear. (From Simpson C V Mosby Co)

Rodent Ulcers —These ulcers are most amenable to radium therapy, particularly the more superficial forms which have less induration and do not involve bone or cartilage Results of radium are much better in cases which have not been previously subjected to ineffectual and misapplied doses of X ray or to caustics solid carbon dioxid, ionization, etc Extensive rodent ulcers, involving bone and cartilage, with hard brawny edges, are very intractable to radium therapy, but in a few instances in which large doses have been used and particularly when combined with very careful cleansing and dressing of the area and by allowing a sufficiently long interval to elapse between the intensive treatments, the results of a few years adres strongen greatly improved |rapy, whicases exten ive operation even when the entire process cannot be removed, is of value when the operative wound is left open sometimes for many months as advocated by Greenough so that the first sign of recurrence may be observed and radiated If kin flaps

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On removing the collodion the remaining papillomata or verrucæ usually respond quickly to radium therapy in one or two treatments

FIG 10—KELOID OF BACK OF NECK RECURRENCE AFTER SURGICAL REMOVAL. Patient referred by Bayard Holmes (From Simpson C V Mosby Co)

Keloids—Excellent results are usually obtained in keloids following wounds, operative or otherwise, or as the result of burns The anesthetic effect in painful keloids may be marked Treatment should not be too intense and must be continued over a considerable period, usually for months

Contractures, War Injuries—Radium has been used successfully in the after-treatment of old war injuries, such as painful scars and fibrous adhesions in joints and about tendons Except when there is extensive and deep scarring, as in the thigh where fairly large doses are required, just as good results are obtained by smaller and more frequently repeated doses

Lupus Vulgaris—The results in some deep seated cases treated by radium are good Very short exposures are employed and great care is necessary Finsen light, however, is undoubtedly best for the routine treatment of lupus vulgaris

FIG 11—PATIENT IN FIG 10 AFTER RADIUM TREATMENT (From Simpson C V Mosby Co)

Lupus Erythematosus—The results of radiations are variable but occasionally may be satisfactory, particularly in obstinate cases

Lichen Planus—Patches of this condition usually yield to radiations in one or two treatments and there may be no recurrence

Pruritus—Short unscreened exposures may produce marked relief of itching The results are particularly good, according to Pinch, if the condition is associated with definite lesions such as leukoplakia or hyperkeratoses, but not so hopeful if the condition is a neurosis

Angioneurotic Edema—Cases of this condition are reported in which considerable benefit and even cure resulted from the use of radiation

Nevi and Angiomata—The value of radiations in the treatment of

nevi is variable Treatment must usually be prolonged for months in the most careful manner In superficial nevi more can be expected if blanching of the tissue is accomplished by gentle pressure The fleshy cavernous nevi in many instances do well under radiation, although, if pulsating the results are more successful if the blood vessel is previously ligated In many cases the treatment must be extended over a long period

Fig 1 —Lupus Vulgaris of Right Cheek in Girl Aged 13 (Taken from *Radium Therapy* by Frank Edward Simpson C V Mosby Co 192)

Miscellaneous Diseases of Skin —Favorable results of radiation have also been reported in the following conditions sycosis favus hypertrichosis alopecia areata, tinea tonsurans hyperidrosis seborrhea acne rosacea comedo psoriasis and chronic eczema

Brain —There is undoubtedly a limited field for the use of radium in conjunction with surgery in the treatment of elected cases of brain tumor In a series of twenty four cases of brain tumor thus treated Frazier reports three in which clinical evidence offers indisputable proof that radium emanations arrested the growth of the tumors and in all probability destroyed them The cases cited have remained well for six seven and eight years respectively

Fig 13 —Patient in Fig 1 after Radium Treatment (From Simpson C V Mosby Co)

Diseases of the Eye —*Carcinoma of the eyelid* —Carcinoma of the lid even the epidermoid variety usually responds in a remarkable manner to radiations and because of the possibility of exact apposition of radium it is preferable to any other form of treatment The result of radium therapy is usually curative and the unsightly deformity and secondary conjunctivitis and its possible sequelæ are avoided The lid remains flexible and smooth and there is practically no loss of tissue except at the exact site of the growth The cosmetic effect is good

Opacities of the Cornea and Lens —Improvement has been reported


14 15

Fig 14 —Cavernous Angioma of Forehead Photograph taken March 1918 (From Simpson C V Mosby Co)

Fig 15 —Patient in Fig 14 after Radium Treatment Photograph taken September 1918 (From Simpson C V Mosby Co)


16 17

Fig 16 —Pigmented Hairy Nevus of Left Eyebrow and Forehead (From Simpson C V Mosby Co)

Fig 17 —Patient in Fig 16 after Radium Treatment (From Simpson C V Mosby Co)

in cases of opacity of the cornea and lens but more experience is necessary before definite conclusions can be drawn

Diseases of Mouth Nose Throat and Ear—*Tuberculosis* and *new growths* in the mouth, nose and throat are usually resistant to radium therapy In certain instances *sarcoma* even if of large size may disappear but recurrence is usual If operable such cases should receive surgical treatment Occasionally *new growths* of the *tonsils* may respond quickly to radium therapy even when the glands of the neck are involved Such growths have usually recurred The results are better if the tubes or needles of radium are inserted directly into the growth In *tuberculosis* and *carcinoma* of the *larynx* radium therapy may give relief but the benefit is only temporary The exact apposition of radium as well as the safety of the patient, is best secured by preliminary tracheotomy In certain instances in which the growth is small and localized particularly in the case of *papillomata* good results have been obtained by the use of radium In carcinoma of the esophagus radium application may cause temporary improvement

Leukoplakia of the buccal mucous membrane reacts variably to radium In some cases a lesion quickly disappears but it is apt to recur In other instances it is refractory to radiation Leukoplakia is often followed by carcinoma particularly when the origin appears to be syphilitic

In *carcinoma of the tongue* the results of radium therapy are not usually good and the treatment may be attended by added suffering In certain instances however the burying of strong tubes of radium in the growths of the tongue has given more favorable result In one instance, a circumscribed growth of border line malignancy with deep papillary projections in a woman considerably past middle age a tube of radium was buried in the growth The latter completely disappeared and there was no recurrence In another case of proved carcinoma of the tongue, after incomplete local excision the residue was treated by radium and there has been no recurrence for seven years

In the nasopharynx and in the *accessory sinuses* in exceptional cases remarkable results may be secured in inoperable or recurrent sarcoma In carcinoma, however, in these regions results have not been satisfactory In the majority of cases epithelial growths on the *lip* are regarded as strictly surgical and this is doubtless the safer procedure The dermatologist however recognizes two types of epithelial lesion of the lip the circumscribed superficial type with slight or marked keratoses readily responds to radium The deeper type even in the very early stages, should be treated by radical excision

Carcinoma or keratosis of the ear if involving the cartilage may prove very resistant to radium treatment and may also be very painful The results are variable depending upon the size and extent of the growth

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FIG 14.—CAVERNOUS ANGIOMA OF FOREHEAD Photograph taken March 1918 (From Simpson C V Mosby Co)

FIG 15.—PATIENT IN FIG 14 AFTER RADIUM TREATMENT Photograph taken September 1918 (From Simpson C V Mosby Co)

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FIG 16.—PIGMENTED HAIRY NEVUS OF LEFT EYEBROW AND FOREHEAD (From Simpson C V Mosby Co)

FIG 17.—PATIENT IN FIG 16 AFTER RADIUM TREATMENT (From Simpson C V Mosby Co)

been radiated. Unless the dosage is well understood, however, the danger of treating such cases must be borne in mind and this is particularly important when such good results are obtained by surgical methods.

Thymus.—Eminently satisfactory results have been reported in the treatment of enlarged thymus glands in infants. The same results may be obtained with the X rays but radium has certain advantages. It is portable, the desired effect is produced in one treatment, it is simple thus eliminating the element of fright which is usually present when infants are held in a rigid position for X ray treatment. This fixation may be the cause of thymic crisis and death. Finally, radium application is a safe procedure as the skin tube distance never varies even in the case of the most refractory child.

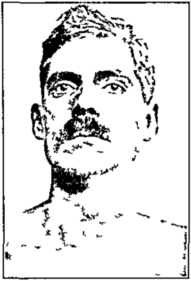

FIG 19.—PATIENT IN FIG 18 AFTER RADIUM TREATMENT. Photograph taken in December 1919. Later recurrences took place in throat, axillæ, inguinal regions and abdomen which yielded for a time to further treatment. The patient had about a year of comfort as the result of the treatment. (From Simpson C A M [illegible])

Pathological Conditions of Chest.—Individual cases have been cited and apparently corroborated by radiographs in which radiation has caused the disappearance of thoracic tumors especially in the case of lymphosarcoma. Hodgkin's disease involving the bronchial glands and lungs has not in our experience shown any permanent improvement on radiation. In *carcinoma of the esophagus* it is difficult to secure accurate apposition of radio active substances but in the majority of cases there is marked temporary improvement. Patients who are almost in extremis from starvation may gain thirty to forty pounds. This is probably due to the repeated dilatation of the esophagus and to the anesthetic effect of the therapy. Recurrences however are usual. It is possible that application by instruments allowing direct observation may improve results particularly in early cases.

Diseases of Breast.—The most important disease of the breast which is subjected to radium therapy is the *recurrent carcinoma*. It is the general opinion that all operable malignant and benign tumors of the breast should be operated upon. Therefore recurrent or inoperable growths form a large part of those treated by radium therapy. The minority comprise a few persons who either absolutely refuse operation

In *tuberculosis of the ear* improvement is usual although the condition is obstinate It has been claimed that small doses of radium have caused marked improvement in cases of *otosclerosis* that the hearing and also such symptoms as tinnitus have improved Other than the improvement that may follow from the encouragement that something is being done, we have seen no such favorable results

Pathological Conditions of Glands—In *lymphoma* and *Hodgkin's disease* the involved glands may be reduced in size by radiation and in certain instances the disease seems to have been restrained Cures are very doubtful and recurrence is usual Kelly and Burnam, however, report 65 per cent of twenty five cases of lymphosarcoma treated by radium as apparently cured and believe that in this disease radium should be used, even in the early stages, in preference to surgery In metastatic carcinoma of the cervical glands, the swelling may be reduced in size, painful pressure may be relieved and the tissues become dense Indeed, it often appears as if in certain instances the progress of the disease was checked by such radiation, but owing to the great variability in the natural course of the primary disease this is doubtful In certain instances large primary or secondary malignant growths disappear under the action of radiations and at the same time the general health of the patient rapidly fails and death may ensue A case of enormous hemolymphangioma of the cervical and subclavicular region in an infant three months of age is reported by Dominici, Cheron, and Barbarin to have completely retrogressed in seven weeks after the introduction for twenty four hours of a silver tube 1/ millimeter in thickness containing 50 milligrams of pure sulphate of radium

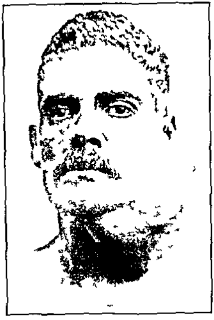

FIG 18—LYMPHOSARCOMA OF NECK Photograph taken July 1919 Note scar of previous operation (From Simpson C V Mosby Co)

In certain instances benign tumors of the thyroid or large goiters have retrogressed to a varying degree by the action of radiations, but carcinoma of the thyroid is only in rare instances favorably influenced Temporary relief of distressing symptoms may occur In cases of *exophthalmic* goiter especially when the thymus is involved, great improvement may result after radiation In certain instances the region of the thymus alone has

which very *frequent aspiration* was necessary, was treated personally by radium applications to the abdomen and the ascites recurred less and less frequently

It is probable that surgery combined with careful application of radiation would greatly improve the present results in abdominal disease

Pelvic Diseases—*Rectum*—In carcinoma of the rectum particularly adenocarcinoma just above the sphincter Burnam reports that some cases *are definitely curable and that in other there is marked improvement* under radium treatment deep carcinomatous ulcers of the rectum are not improved, although polypi may do well Certain of the squamous-cell carcinomata about the anus are much improved by radiation and others are less so Preliminary colostomy is advisable

Bladder—Chronic ulcers of the bladder may be improved by radiation, and also papillomata although in the latter fulguration is probably preferable The papillary type of carcinoma is more favorable than the squamous-cell variety In applying radium it is better to open the bladder and thus make more exact application for the requisite time

Prostate—It is reported that hypertrophy of the prostate is improved in certain instances Numerous cases have been reported In our experience carcinoma of the prostate has not been cured Larger doses and better *methods will doubtless secure more favorable results* Bugbee claims better results from exposure of the prostate suprapubically destruction of the cancer by radium needles introduced through the prostate from above close to and parallel with the urethra and from needles introduced into the prostate through the perineum and late surface radium applications accurately made while drainage is maintained Application to the prostate through the rectum is also advisable The *term cure* should not be used in these cases

Testicle—Embryomata of the testicle particularly the cellular so-called round-cell sarcoma may yield to radiation even when the regional glands are involved We now have under observation in apparently perfect health a young adult in whom there is no sign of recurrence even though the inguinal glands were involved when the testicle was removed and radiation started two years ago

A great deal has been written particularly within the last few years concerning the value of radium treatment in gynecology Indeed the subject has been taken up by some of the foremost gynecologists in this *country and more especially in Europe About ten years ago some of* the European gynecologists made astounding statements regarding the beneficial effects of radium in cancer of the uterus but some of these same ... made the most disparaging remarks concerning its use ... undoubtedly has a large field of usefulness in gynecology ... obtained depend in a large measure upon the ... and the accuracy of the application to the lesion

or whose general condition will not permit an operation and those who are treated postoperatively in prophylaxis of recurrence In the last class of patients it is difficult to estimate the value of such treatment until a very large number of cases has been carefully followed out and comparative series analyzed In certain instances recurrent superficial skin nodules disappear completely There is little doubt that the smaller and more cellular growths respond quickly to radiation, but at the present time proper surgery should be the treatment of choice in all operable tumors of the breast It is probable that radiation by the deep method for very long periods of time may delay the progress of the disease even when cure cannot be expected The great variability in the natural history of the disease, however, renders this somewhat doubtful When the disease is widespread with mediastinal, pleural, or pulmonary involvement, or there is general carcinomatosis, little can be expected from radiation

Abdominal Conditions—Certain abdominal tumors become smaller and may disappear on deep and intense radiation In this class are large retroperitoneal sarcomata, lymphomata and cases of splenomegaly Cases are reported in which sarcomata and hypernephromata have disappeared. Details of the cases are reported by very few, so that it is difficult to know the degree and duration of the clinical improvement In cancer of the gastro-enteric system there is little evidence that radiation has proved of any value In the majority of such cases, treated personally there has been a marked relief of pain and patients have even felt that it was worth while to go considerable distances for treatment in order to secure even temporary relief, usually only a few days or occasionally a few weeks duration It is, of course, quite probable that a certain degree of relief in these cases of malignant disease was due to the encouraging fact that something was being done

In a case of adenocarcinoma of the uterus with transplantation of the growth in the fat of the abdominal wall, the large and inoperable mass entirely disappeared under two series of intensive radiation by radium After the first series the growth became much smaller and the second series was given shortly afterward, instead of allowing the usual four to six weeks interval, at the entreaty of the patient and her husband, although it was carefully explained to them that burning of the skin would probably result The latter occurred and it was some months before the pain and burns healed However, the tumor mass had not recurred two years later and the patient's general health was excellent This case is an exception and not the rule

Certain cases of ascites from abdominal cancer have been reported relieved, but the variability of such cases naturally leaves the actual value doubtful

A case of syphilis of the liver, with extremely marked ascites for

which very frequent aspiration was necessary, was treated personally by radium applications to the abdomen and the ascites recurred less and less frequently

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Prostate—It is reported that hypertrophy of the prostate is improved in certain instances Numerous cases have been reported In our experience carcinoma of the prostate has not been cured Larger doses and better methods will doubtless secure more favorable results Bugbee claims better results from exposure of the prostate suprapubically destruction of the cancer by radium needles introduced through the prostate from above close to and parallel with the urethra and from needles introduced into the prostate through the perineum and late surface radium applications accurately made while drainage is maintained Application to the prostate through the rectum is also advisable The term cure should not be used in these cases

Testicle—Embryomata of the testicle particularly the cellular so called round-cell sarcoma may yield to radiation even when the regional glands are involved We now have under observation in apparently perfect health a young adult in whom there is no sign of recurrence even though the inguinal glands were involved when the testicle was removed and radiation started two years ago

A great deal has been written particularly within the last few years concerning the value of radium treatment in gynecology Indeed, the subject has been taken up by some of the foremost gynecologists in this country and more especially in Europe About ten years ago some of the European gynecologists made astounding statements regarding the beneficial effects of radium in cancer of the uterus but some of these same men later made the most disparaging remarks concerning its use Radium therapy undoubtedly has a large field of usefulness in gynecology The valuable results obtained depend in a large measure upon the intensity of the radiation and the accuracy of the application to the lesion

to be treated The resistance of the pathological tissue, the length of exposures and the intervals between them is determined by the clinical judgment of the operator

Vulva—Most of the patients with carcinoma of the vulva have post operative recurrences and the majority have metastases In such cases radium therapy has proved of little value, except in cleansing the local condition and in relieving hemorrhage Pruritus and leukoplakia may be greatly relieved

Vagina—The fungating type of cancer of the vagina may yield quite readily to radiation In the indurated type results are not good and sufficient radiation is apt to cause a formation of fistulæ They are also apt to occur in the natural course of the disease whether primary or secondary One case was treated personally with radium in which an invasive indurated recurrent carcinoma disappeared and the large recto-vaginal fistula resulting was successfully closed by a gynecologist and remained healed

Leukorrhea may be relieved by radiation although the possibility of at least temporary amenorrhea should be remembered Polypi of the vagina are usually cured by radium therapy

Uterus—In carcinoma of the body such excellent results are obtained by proper surgical measures that only for exceptional reasons should radium therapy be employed, except in inoperable cases Of cases of carcinoma of the cervix however, only a very small percentage are distinctly operable when first seen by a competent physician, it is in this group of cases, therefore, that radium therapy finds its greatest usefulness.

Although much has been written concerning radium therapy in cancer of the uterus, not a sufficient number of cases have been studied and carefully followed up to recommend any treatment except an operation, in cases which are operable, unless the general condition of the patient contra indicates or the family are unwilling to consent to an operation In addition to these inoperable cases radium therapy is used in post operative recurrences and after operation in prophylaxis of recurrence In the inoperable and recurrent cases of carcinoma of the cervix the results are in a large measure palliative One unfamiliar with the course of the disease as modified by radium treatment would be inclined to think, after a few series of treatments, that the condition was cured The term "healed," applied by some observers, we believe is misleading for the reason that under the first few series of radium treatments fungating carcinomata of the cervix may disappear, and the ulceration in the ulcerating indurated type may become less and less and finally apparently heal, and the induration about it may be markedly lessened Such a condition might be called healed and lead to the natural supposition that the process was cured This, however, is not usually the case Sooner or later, the disease extends, even if it does not recur locally, and the patient suc-

cumbs to it Certain cases however, distinctly inoperable at the out set even with fixation of the uterus and metastases in the vaginal wall may, after the primary improvement and local healing be successfully operated upon Thus distinctly inoperable cases may exceptionally be converted into operable ones Sometimes growths which respond promptly to the first series of radiation later become resistant to all radiation treatment. In certain instances it is desirable to combine local vaginal treatment with applications of radium to the abdominal wall and back, in order to increase the cross fire effect. At least temporary relief from hemorrhage, discharge, and pain and healing of ulceration are common in carcinomata of the uterus treated by radiations Some cases may remain well for months or even years

After radiation, a small number of cases of carcinoma of the uterus develop so-called toxic symptoms which include headache vomiting prostration, and rise in temperature There may also be such local symptoms as pain in the back and legs tenesmus or frequency of micturition These symptoms disappear in a few days

Schauta, in his series of cases in 1913, used intense radiation and many of the patients developed extensive local necrosis The tendency of the majority of those using radium at the present time is to use a dose of about 100 milligrams of radium element 2 millimeters of lead or 1 to 1½ millimeters of brass, or its equivalent in silver or platinum for filtration and a duration of exposure of twelve hours every few days for five to eight treatments At intervals of six weeks the series is repeated Such cases rarely develop fistulae or extensive necrosis and there is at least temporary local and general improvement Kelly and Burnam have reported that of 199 inoperable cases treated 53 were clinically cured 108 markedly improved and 37 not improved Schmitz used 50 milligrams of radium in cases of carcinoma of the uterus for ten to twelve and occasionally twenty four hours and repeated this after from seventy two to ninety-six hours After having given a dosage of from 3 000 to 4,000 milligram hours he gave the treatment weekly, until he had given a total dosage of from 8 000 to 10 000 milligram hours Bumm found that all cancer cells were destroyed within a distance of 4 centimeters but that they were viable beyond this Cheron and Rubens Duval made a postmortem examination of a patient dying of an intercurrent disease fifteen months after the clinical cure of carcinoma of the uterus by radium In a complete postmortem and careful serial histological examination they were unable to find cancer cells

The scirrhous, inverting type of carcinoma of the uterus seems usually less improved than the more fungous everting type which tends to involve the vaginal walls During and between treatment it is important that the local condition be kept as clean as possible by a mild cleansing solution of boric acid bicarbonate of soda or potassium permanganate

A few cases of chorio-epithelioma have been reported treated by radiation. These cases, in most instances, metastasize to the lungs early. Owing to the few cases of sarcoma of the uterus treated no conclusions can be drawn.

Of the *benign tumors of the uterus* fibromata and fibromyomata have been extensively treated in this country and abroad. Although there is much skepticism regarding the results, a large number of cases have now been reported in which the size of the growths has diminished or they have entirely disappeared. It is admitted that certain small percentages seem to be uninfluenced. In the majority of cases, however, not only does the tumor diminish in size but the symptoms of menorrhagia or metrorrhagia cease. Both intravaginal and surface applications are made. Amenorrhea is caused in the majority of cases. Some of the foreign clinics report 80 per cent of cures in cases of myomata treated by radium. Kelly has used 30 to 724 milligrams of radium inserted into the uterus and has, in some cases, given an additional massive treatment through the abdominal walls. The treatment requires confinement of the patient to the bed for not over one or two days.

Menorrhagia and Metrorrhagia.—These conditions, unassociated with the presence of tumor, due to various myopathies or neuropathies or to disturbed ovarian function are, in the large majority of cases, very greatly benefited or cured. Burnam uses 300 milligrams of radium applied within the uterus for three hours. This usually causes complete amenorrhea. In young women the duration of application is shortened, 500 milligram hours or less, and in such instances menstruation may return.

L. J. Stacy reports the results of radium treatment in 600 cases of menorrhagia and concludes that, while surgery is still the method of choice for young women who have definite fibroids causing menorrhagia and those with a suspected carcinoma of the fundus, Roentgen rays and radium are successful therapeutic agents in carefully selected cases and *in women over thirty five. In the treatment* of menorrhagia in patients more than thirty five years old, who have a fibrous uterus or a small myoma, and in younger patients in whom myomectomy or hysterotomy is not indicated or in whom curettage has not controlled the bleeding radium is a very satisfactory therapeutic agent.

Radium is contra-indicated in pelvic inflammatory disease or where there is a history of pelvic pain, since a quiescent infection may be lighted up.

A small dose is given women under thirty five in order to control bleeding but not to cause cessation of menses. *It is better to repeat the* treatment a second time than to cause the menstrual flow to cease entirely by too large an initial dose. The average dose used was 293 milligram hours for patients under thirty five and about 700 milligram hours for older women.

Artificial Menopause—Radium may be used successfully in cases where it may seem desirable to produce an artificial menopause. A routine curettage with histological examination of the curettings to exclude new growth should precede the application of radium in most cases of uterine bleeding even in young women.

SUMMARY

Radium has been proved to be a physical agent of unique character. It has been shown to have a destructive action upon certain kinds of tumor cells. However, the cherished hopes and the fantastic claims that it would cure malignant disease and ultimately replace surgery have not been realized. In speaking of cures by radium we must be very guarded and must consider the type of growth with which we are dealing. Definite and permanent cures of superficial cancer of the skin of the basal celled type are obtained in the majority of cases properly treated by radium. Rapidly growing cellular types of malignant disease often show astounding temporary regression for varying periods. Malignant tumors which are less cellular and those which metastasize early fail as a rule to respond so well even temporarily. There are however exceptions to this rule. Marked clinical improvement with disappearance of all visible or palpable signs of the disease does not necessarily mean a permanent cure. Careful histological study of these apparently normal tissues will show in the vast majority of cases that not all the tumor cells have been destroyed but that scattered groups lie enmeshed in fibrous tissue and surrounded perhaps, by lymphocytes—a barrier by no means impervious to subsequent growth and metastasis. With complete clinical cure of the primary tumor there may still exist extensive regional or remote involvement. A cure can be obtained only when the last single abnormal cell has been destroyed. Up to the present time this has been impossible in the great majority of cases.

The palliative effect of radium in relieving hemorrhage, pain, discharge, foul odor and in prolonging life temporarily in many instances is undisputed.

There is an occasional case of proved malignant disease where the patient remains cured for ten to fifteen years and perhaps permanently. The undue prominence given to these cases which are exceptions rather than the rule has given rise to the extraordinary and fanciful claims which have been made by some for the curative power of radium.

Radium as a medicinal agent taken internally has perhaps some value but as yet there is not sufficient carefully collected data to substantiate the claims made for it.

It is hoped that in the future the accuracy of the diagnosis of all cases treated by radium may be carefully corroborated by histologic examina-

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It is hoped that in the future the accuracy of the diagnosis of all cases treated by radium may be carefully corroborated by histologic examina

tion of tissue removed for this purpose, and that such cases will be followed for end results, so that we may have an ever increasing volume of accurate statistics upon which to base our judgment as to the ultimate value of radium as a therapeutic agent

Improvement in the results obtained may possibly come in the future by the more accurate methods of application of radium to the pathologic cells in question, so that fewer escape its destructive action than is at present the case Careful study of the unusual cases which are apparent cures for long periods may shed light on the optimum method of application and dosage

CHAPTER XIV

X RAY THERAPY

JOHN REMER

Introductory—The discovery of the X ray marked the beginning of a new era in medicine from a therapeutic as well as a diagnostic standpoint The physical properties of these rays, by which they can penetrate matter opaque to light, and their effect on the photographic plate, afforded a means of visualizing conditions within the body which previous to this time could be diagnosed only by their symptoms and clinical signs Their biological action provided a therapeutic agent to combat successfully many diseases and conditions which had previously responded unsatisfactorily, if at all to medication and other forms of treatment

Although numerous other workers had been experimenting along the same line, it was Roentgen who in November, 1895, gave the results of his discovery to the world It was but a few months after Roentgen s discovery that other experimenters called attention to the biological action namely, that by exposure to the ray erythema or dermatitis was produced This led to the hypothesis that in the discovery of the X ray an agent of therapeutic value had been found Its first use was directed to the treatment of the more resistant and of the incurable skin conditions such as lupus epithelioma, and hypertrichosis

As is usually the case when a new therapeutic agent is given to the profession, the X ray was considered a panacea During the next few years there was scarcely a condition that was not subjected to this form of therapy The natural result of this widespread indiscriminate and frequently unintelligent use of so dangerous an agent was that the literature was soon filled with reports of burns varying in severity from mild vesiculation to a necrosis of even the deeper tissues Then followed a period in which the use of the ray in therapeutics was looked upon with great disfavor by the profession at large only a few of the more earnest and persevering workers continuing its use As a result of the painstaking research and experimental work of these few certain basic principles governing X ray therapy were established The most important of these are

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terminal, and within the tube are placed the anode or 'target,' which is usually made of tungsten and the cathode which is usually a cup-shaped metal disc so arranged as to focus the stream of electrons on the center of the target There are in use to-day two types of tubes first, those depending for the electrons on a small amount of gas left within them, called gas tubes second those which supply electrons from a heated wire or filament placed at the cathode and known as the hot cathode or more familiarly, Coolidge tubes in honor of their inventor, Dr W D Coolidge

Gas Tubes—Gas tubes contain a small amount of air (or other gas) from which in its rarefied state electrons are readily liberated The current entering at the cathode directs these electrons against the target (at a speed equal to one-third to one half the velocity of light) where they are abruptly stopped and at which point the X rays are generated Continued use diminishes the supply of electrons and causes the tube to become hard that is it requires greater voltage to operate Therefore a device must be supplied that will permit more gas to be admitted as required To accomplish this a valve containing certain chemicals (usually mica or asbestos) is placed in the side of the tube When a small discharge current is passed through this valve gas will be liberated into the tube This procedure is called 'softening' The tendency of the gas tube to harden makes impracticable its use in therapeutics where a constant and uniform tube resistance must be maintained since a change in this factor alters the character and amount of the radiation produced and, also any variation makes it impossible to estimate accurately the amount of radiation generated

Coolidge Tube—The general construction of this tube is similar to that of the gas tube but the air is exhausted to such a point that the greatest possible vacuum is obtained In the cathode is placed a coil of tungsten wire connected to a low voltage electric current (supplied by a storage battery or a step-down transformer) When the circuit is closed the coil (or filament) becomes heated and liberates electrons The hotter the filament the softer the tube By means of a current control the temperature of the filament can be regulated at will so that the tube may be maintained at any given degree of hardness for an indefinite length of time It was the advent of this type of tube that overcame one of the greatest difficulties confronting the radiotherapeutist, and since its invention the progress of radiotherapy has been marked

Transformer—In the early days of the X ray the electrical current was supplied by static machines These were soon replaced by various types of induction coils, which although more satisfactory have in more recent times been supplanted almost entirely by the 'interrupterless transformer' This machine consists of a primary winding around a soft iron core and an extensive secondary winding in which the high tension

1 That the beam of rays as generated by the X ray tube is not homogeneous, but is composed of radiant energy of varying wave-lengths.

2 That these varying wave-lengths have a different biological action, the longer ones having little penetrating power and being absorbed by the skin, while those of shorter length penetrate to the deeper tissues

3 That on the depth of the lesion depends the type of ray which is most effective

4 That certain substances, such as aluminum, glass, copper or zinc, when interposed in the path of the ray, filter out or eliminate the soft rays, that is, those of long wave-length This makes possible the utilization of the type of ray best suited to the case under treatment

5 That the skin will tolerate only a limited amount of radiation

With the establishment of these principles, there came a reaction, and the value of X ray as a therapeutic agent was established

PHYSICS

X ray is a form of radiant energy which is produced when a stream of electrons, set in motion in a vacuum at a high rate of speed, are suddenly stopped It is similar to light, and travels with the same velocity

X rays move in all directions from the point of source, until absorbed by matter The capacity of matter for absorbing these rays is in direct proportion to its atomic weight The beam of X rays is heterogeneous, being composed of rays of various wave-lengths The alpha rays are the longest and are spoken of as "soft rays", the "hard rays" or those of shortest length, approach very nearly the gamma rays of radium X rays are invisible, and can be detected only by their action first on the photographic plate, second, on certain crystals third on tissue (biological action), fourth on the ionization chamber, and fifth, by their place in the spectrum

In order to produce X rays it is necessary to have

1 A vacuum

2 A source or supply of free electrons

3 A heavy metal "target," placed in the path of the stream of electrons

4 A means of setting the electrons in motion at a high rate of speed

The first three are found in the X ray tube while the fourth is supplied by some form of electrical apparatus, that known as the "X ray transformer" being the most efficient

X ray Tube—The X ray tube is a glass bulb from which all or nearly all, of the air has been pumped At either end is an electrical

thousandth of an ampere Any change in the milliamperage changes the quantity of radiation The higher the milliamperage, the less time required to produce a given amount of ray with a given spark gap In radiotherapy two to seven milliamperes are usually employed a greater amount causing the tube to heat too rapidly for practical therapeutic purposes Furthermore, longer irradiation is frequently advantageous on account of the greater amount of secondary radiation produced

Distance—Distance represents the number of inches or centimeters from the target of the tube to the nearest surface of the body This factor is varied according to the preference of the operator

Time—This factor is the actual time that the X rays are being directed to the surface under treatment

Filter—In order to eliminate the soft rays, various substances are interposed between the skin and the target of the tube The filter is placed in a slide arranged in the tube-stand for that purpose The substances generally employed are glass aluminum brass copper and zinc Sole leather is used by some as are paper chamois skin and silk but these are of questionable value The greater amount of filtration used, the less total radiation reaches the patient but as the soft rays are the most easily eliminated it is possible by proper filtration to utilize only the most penetrating rays thus delivering a more homogeneous ray

Another factor which is of importance in considering the amount of radiation delivered to the lesion is the size and number of areas treated Depending somewhat on the choice of the operator but more on the location and character of the lesion this factor varies greatly In superficial therapy it is necessary to expose an area only slightly larger than the lesion itself In deep therapy however it is frequently necessary to expose the anterior, posterior and lateral surfaces of the body, in order to deliver to the lesion a sufficient quantity of ray without injury to the skin Again by exposing small areas and carefully shielding the surrounding skin it is possible without harm to the patient to give much larger quantities of ray to a given portion of the body than if only one area were used Furthermore, the larger the area exposed the greater the amount of secondary radiation produced

No absolute or fixed rule can be given governing the conduct or treatment of any particular condition and in outlining the treatment of various diseases the author is merely indicating the method found beneficial in the treatment of the majority of cases It must be remembered however that every case is an individual one and that the success of the radiotherapeutist depends above all on his ability to recognize the special requirements of each patient and his ingenuity in meeting them

To say that accurate diagnosis is of the greatest importance and that X ray treatment should never be undertaken until it has been established may seem an affront to the profession However as results depend largely

or secondary current is induced The current supplied to the primary is usually 110 or 220 volts, and must be alternating current The current obtained from the secondary is from 10,000 to 200,000 volts, and is also alternating In order to operate the X ray tube direct current is required, and a rectifier is placed in the secondary circuit which makes it possible to deliver the proper type of current to the tube[1]

There are certain electrical and physical factors which govern the quality and quantity of X ray, and by which the amount of radiation applied may be estimated In considering the amount of exposure, these factors are most important, and it must be borne in mind that a change in any one of them alters the character or amount, or both, of the radiation applied The important factors are spark gap (voltage), milliamperage, distance, time, and filter

Spark Gap (*the Unit of Voltage*) —The unit of measurement of difference in potential between the positive and negative side of an electrical apparatus is the volt, and is usually measured by a voltmeter Due to various mechanical and electrical difficulties, it has been, in the past, advisable to use an approximate method of measuring the high tension voltage instead of a meter Electrical currents always follow the path of least resistance The X ray tube offers resistance which varies in direct proportion to its hardness If a wire or metal rod is so placed that it can be extended from one side of the secondary line toward the other, a point will be reached at which the current will encounter less resistance by jumping the gap between this rod and the other side of the circuit than in passing through the tube This space is called the spark gap (S G) and has been the commonly used method of expressing voltage in computing the amount of X ray administered

A one-inch gap represents, approximately, 20,000 volts, and each additional inch represents 10,000 volts so that a nine-inch spark gap is considered equivalent to 100,000 volts In the latest type of machine (the 200,000 volt) there is a tendency to speak in terms of volts rather than spark gap Also, in these machines the measure of the spark gap is between spheres instead of points

Any change in distance that the current will jump represents a change in voltage hence a change in the quality of radiation The longer the gap, the more penetrating the ray In radiotherapy a six to fourteen inch spark gap is employed

Ampere —The ampere is the unit of electrical current and represents the amount of electricity passing a given point in a certain length of time In roentgenology the amount of current used in the secondary line is so small that the measurement is the milliampere, and represents one-

[1] Certain types of tubes can be operated on alternating current and the modern portable or bedside X ray outfit is thus made possible In treatment however this type of tube and machine is impracticable

Some investigators believe that minute exposures have a stimulating action but the author does not agree with this contention believing that the action of the ray is always inhibitory. It is true, especially in neoplasms, that insufficient radiation will frequently be followed by an increased activity of the tumor but this is probably due to an inhibition of the surrounding normal tissue and interference with the normal blood and lymph supply to the part instead of to a stimulation of the growth. The same result will be produced by too prolonged radiation.

The response of tissue to radiation varies according to the type of cells of which it is composed. Normal cells are more resistant than pathological, and the nearer the cell approaches the embryonic type the greater and more complete the effect. Conversely the more closely the pathological approaches the normal the greater its resistance. But this resistance is always below that of the normal. Ewing states that while normal lymphoid tissue is very resistant to the action of the ray, the same type, when pathological, is quite easily destroyed by it. It is due to this fact that it is possible to use the X-ray therapeutically, for when the ray is applied to a pathological area normal tissue is necessarily exposed to its action and were all cells equally affected it would not be possible to destroy the diseased tissue without at the same time destroying normal structure. Obviously it is the area of the skin nearest the target that receives the greatest amount of radiation hence the limit of ray that can be applied must be no greater than the skin will bear without serious injury.

The second, and equally important factor in tissue response is its ability to recover from inhibition. This recovery is in inverse proportion to the degree to which it is affected, the tissue most difficult to affect recovering most rapidly and most completely. Since the pathological cells recover less rapidly and less completely than the normal it is possible to administer a second exposure as soon as the normal structures have recovered and while the pathological are still inhibited. This second radiation still further inhibits the lesion without injury to the normal tissue and by repeated exposures it may be possible to destroy the lesion completely.

Thus it can be readily understood that cases selected for X-ray treatment must be those in which there is pathological tissue present and this pathological tissue must be simple inflammatory, chronic inflammatory, granuloma or neoplastic that it must be possible to destroy the tissue without causing serious injury to normal structures. In fibrous lesions, where only connective tissue is present no benefit will be derived.

Although all tissues will return to their normal activity within a definite time after being subjected to the action of the X-ray their resistance remains lowered for a much longer period. Consequently if treatments are continued for too long a time without suitable intervals of

on proper technic, and since this technic varies so widely, there is constant danger either of affording no relief or of actually doing harm, unless a correct diagnosis is established This applies not only to superficial therapy, in which various lesions may so closely resemble each other as to be indistinguishable to the untrained observer, but to the entire field of deep therapy as well

In the development of the 200,000 volt technic, every effort is being made to standardize all factors, and extensive experimental work has been, and is being conducted by radiotherapeutists in collaboration with physicists and biologists Absorption of X ray by tissue has been carefully studied, and curves plotted to show the exact amount absorbed by each successive centimeter Investigations are being conducted to estimate the amount of secondary radiation produced In this work the ionization chamber is employed to measure the amount of radiation and in every way efforts are being made to advance the technic along thoroughly scientific and absolute lines However, the fact must not be overlooked that *medicine in all its branches is an art, and not a science, that* biological reaction cannot be accurately measured, nor can the effect of an agent on living, cellular life be considered the same as its effect on inorganic or non living material So that, while this work is in the right direction and of inestimable value, the individuality of each case must govern its treatment

In the use of the newer method there is considerable variation in technic Filters employed vary from ½ to 1 millimeter of copper plus 1 millimeter of aluminum The distance ranges from 40 to 100 centimeters, and the area of exposure is from 10 to 25 centimeters square

By accurately locating the tumor, carefully measuring the body and from the charts of absorption curves estimating the number of portals and amount of radiation necessary to each portal, the growth will receive the required percentage of an erythema dose, and at no point will the skin receive a greater amount than is compatible with safety

GENERAL CONSIDERATIONS OF X RAY THERAPY

Before beginning a discussion of the merits and limitations and the various methods of administering X ray for therapeutic purposes, it is desirable that there should be a clear conception of its action In speaking of the various means of detecting the ray, the biological action and its effect on living cells was described This effect is inhibitory and varies in degree in direct proportion to the amount of radiation applied If sufficient is administered, complete destruction or necrosis of the cell follows

Some investigators believe that minute exposures have a stimulating action but the author does not agree with this contention, believing that the action of the ray is always inhibitory It is true especially in neoplasms, that insufficient radiation will frequently be followed by an increased activity of the tumor but this is probably due to an inhibition of the surrounding normal tissue and interference with the normal blood and lymph supply to the part instead of to a stimulation of the growth The same result will be produced by too prolonged radiation

The response of tissue to radiation varies according to the type of cells of which it is composed Normal cells are more resistant than pathological and the nearer the cell approaches the embryonic type the greater and more complete the effect Conversely the more closely the pathological approaches the normal the greater its resistance But this resistance is always below that of the normal Ewing states that while normal lymphoid tissue is very resistant to the action of the ray the same type when pathological is quite easily destroyed by it It is due to this fact that it is possible to use the X ray therapeutically for when the ray is applied to a pathological area normal tissue is necessarily exposed to its action and were all cells equally affected it would not be possible to destroy the diseased tissue without at the same time destroying normal structure Obviously it is the area of the skin nearest the target that receives the greatest amount of radiation hence the limit of ray that can be applied must be no greater than the skin will bear without serious injury

The second and equally important factor in tissue response is its ability to recover from inhibition This recovery is in inverse proportion to the degree to which it is affected the tissue most difficult to affect recovering most rapidly and most completely Since the pathological cells recover less rapidly and less completely than the normal it is possible to administer a second exposure as soon as the normal structures have recovered and while the pathological are still inhibited This second radiation still further inhibits the lesion without injury to the normal tissue and by repeated exposures it may be possible to destroy the lesion completely

Thus it can be readily understood that cases selected for X ray treatment must be those in which there is pathological tissue present and this pathological tissue must be simple inflammatory chronic inflammatory granuloma or neoplastic that it must be possible to destroy the tissue without causing serious injury to normal structures In fibrous lesions where only connective tissue is present no benefit will be derived

Although all tissues will return to their normal activity within a definite time after being subjected to the action of the X ray their resistance remains lowered for a much longer period Consequently if treatments are continued for too long a time without suitable intervals of

rest, atrophy of the skin and subcutaneous tissue will result, although at no time has there been sufficient radiation administered to cause even a mild erythema Some tissues, most noticeably carcinoma, seem to acquire a tolerance for X ray In cases of cancer it has frequently been noted that, although at first satisfactory progress was made, later the neoplasm increased in size, and the condition of the patient became steadily worse, even though the same or even a greater amount of radiation was administered To this fact is due the present-day effort of therapeutists, especially *those using the more recent high power machines, to administer* the full, so-called, carcinoma or sarcoma lethal dose at a single treatment

EFFECT OF X RAY THERAPY ON TISSUES

Skin—As mentioned above the effect of the X rays on the skin is the guide to the amount of radiation that can safely be administered If the amount of radiation is increased beyond safe limits there is produced (1) erythema, (2) vesiculation and depilation, and (3) ulceration and necrosis Complete and permanent alopecia may result, and the functions of the glands may be permanently inhibited This subject will be treated at greater length in a subsequent paragraph

Circulatory System—*Blood*—Within twenty four hours after radiation there is an increase in the white blood count, due entirely to new *polymorphonuclear elements The lymphocytes are decreased* resulting in a leukocytosis, together with a lymphopenia The increase in the polymorphonuclear cells is probably caused by destruction of the lymphocytes, which calls upon the body for increased phagocytic action This condition persists only a short time, perhaps only a *few hours,* and is succeeded by a true leukopenia This reaction, to a varying degree, always follows the administration of X ray, but unless the blood forming organs are radiated, the effect will be very transitory Hence, in order to obtain beneficial results in the leukemias, the long bones, *the spleen,* and lymphatic glands must be exposed

The effect on the red cells is slight, and it is only after massive administration that the presence of degenerated, or nucleated, forms is noted Some authors consider this effect of great importance attributing to it a peculiar cachexia which has been observed after prolonged radiation

The theory has been advanced and some experimental work has been done to prove, that X ray causes an increase in the antibodies of the blood Clinically it is well demonstrated that results are obtained in parts of the body distant from those radiated In Hodgkin's disease, frequently only the trunk is radiated, regardless of the position of the glands involved, and yet a diminution or disappearance of all affected glands is obtained

Again, in leukemia blood taken from a patient who had received radiation was injected into a second patient suffering from the same disease, but who had not been so treated The white blood count of the latter was reduced When this same experiment was tried, using the blood of a non radiated patient no such result was obtained It is believed by some workers that this antibody reaction is an important factor in carcinomatous conditions and that the beneficial results are due to it, as well as to the destructive action of the ray on the neoplasm The coagulation time of the blood is materially shortened

After a very massive exposure especially about the head and neck, an edema in the area exposed is frequently observed This is variously accounted for some workers contending that it is due to vasodilatation with consequent venous stasis others holding that a proliferation of the lymphatic endothelium is produced which causes a lymph stasis The latter view seems to be the correct one, and is of importance in the preoperative radiation of malignancy

Eyes—The widespread belief that the eye is especially sensitive to the X ray seems to be without clinical foundation Although it is true that conjunctivitis superficial keratitis iritis retinitis and even optic atrophy have been experimentally produced in small animals it was only after radiation had been carried far beyond the amount tolerated by the skin In actual practice it has been found that the vision is in no way impaired when the eyes are unprotected during treatment of lesions about the face lupus epithelioma, etc As a precautionary measure most workers when exposing lesions of the face cover the eyes with a lead shield, and while this is probably unnecessary the medicolegal aspect must ever be borne in mind and operators will do well to employ all possible precautions

Kidneys—Normal kidney tissue is not affected by X ray administered in therapeutic amounts Nevertheless massive radiation of the body is sometimes followed by clinical and urinary evidence of acute nephritis This is probably the result not of the action on the kidneys but of the added strain placed upon them in consequence of the sudden liberation into the blood stream of toxic material from the disintegrated tissues which received radiation In kidneys already pathological such a nephritis is more apt to occur and to prove more serious

Nervous System—Nerve tissue is not affected by rational exposures Tumors of the brain have been successfully radiated and no evidence of impairment of brain function followed

Lungs—It has been observed that prolonged radiation over the thorax sometimes causes fibrotic changes in the lungs Several cases have been reported in which pleural effusion followed the application of massive exposures with the 200 000 volt technic Otherwise there is apparently no effect. Both the effusion and the fibrosis disappear

Thyroid and Thymus—The effect on the thyroid has been recognized, and the X ray used for treatment of toxic hyperthyroidism for many years Moderate amounts of the ray cause a decrease in the function, and if sufficient ray is administered myxedema will result This effect is considered by many physicians to be a contra indication to the use of radiotherapy for lesions around the throat and neck Such contention is not justified by the experience of radiotherapeutists, who find that to influence hyperthyroidism the ray must be directed to the gland itself, and that prolonged series of radiations for cervical adenitis, and the procedures followed in treating hypertrophied tonsil, do not cause the slightest evidence of diminution of thyroid secretion

Larynx—Over radiation of the larynx may cause temporary or permanent aphonia

Spleen—This organ is especially sensitive By animal experimentation it has been found to shrink rapidly after being exposed to the ray At necropsy it was found to be shriveled and discolored, the cellular elements destroyed, and the lymphocytic nuclei disintegrated

Gastro intestinal Tract—*Salivary Glands*—Exposures to even a sub-erythema intensity of filtered radiation may be followed by dryness of the mouth and throat, which persists a day or two, due to an inhibition of the glandular activity If sufficient exposures are given, permanent loss of the activity of these glands will result

Stomach—Cases of hyperacidity treated by X ray have had the amount of acid reduced, and their symptoms relieved While no special investigative work on this subject has been recorded, it seems reasonable to suppose that all glandular activity may be inhibited by the X ray, hence, not only the hydrochloric acid glands, but all others as well, are probably inhibited

Intestine—Martin and Rogers, in their investigations, found that massive exposures to X ray, particularly with the 200,000 volt machine, directed over the intestines, caused an endothelial necrosis Having determined the quantity of radiation necessary to produce an erythema on a dog's skin, they exposed a loop of the animal's intestine (laid on the belly wall after laparotomy) to the direct action of the ray Two groups of animals were radiated, the first receiving the erythema exposure, the second, twice that amount

At the end of three weeks the first group of animals showed no clinical evidence of any untoward effect of the ray An autopsy performed at this time showed that the exposed loop of intestine was shortened two-thirds of its length, its lumen narrowed, its epithelium desquamated and all villi absent The loop was hyperemic, the mucosa thickened, and the muscularis vacuolated

Animals of the second group were clinically well on the fourteenth day, but refused food on the sixteenth They then rapidly lost weight,

and on the nineteenth day their condition was such that they had to be killed At autopsy the same condition was found as was observed in Group 1, but to a more advanced degree Their conclusions in part are

1 The erythema dose for a dog's skin when applied directly to the intestine produces hyperemia marked contraction in all directions, and destruction of the epithelial lining

2 The intestinal damage to dogs resulting from direct radiation, does not always produce early death

3 Bloody diarrhea, ulceration perforation and stenosis occurring in patients subjected to deep therapy for abdominal lesions may be due to direct intestinal injury

4 Roentgen cachexia is possibly due to the same cause

These experiments are of particular value at the present time since in the attempt to overcome carcinoma efforts are being made to deliver a depth dose of 110 per cent of the erythema exposure

Reproductive Organs —The belief that sterilization may follow the least exposure to X ray is so firmly fixed in the minds of many that it seems advisable to speak at some length on the subject in order that the widespread fear of the ray, on this account may be dissipated

It is true that both the testicles and ovaries are sensitive to the ray and that, following sufficient exposure aspermia or premature menopause will occur The effect is mainly on the germinal epithelium which can be completely destroyed but only after relatively heavy radiation certainly not after a single fractional exposure such as is received by persons visiting an X ray laboratory at infrequent intervals

By animal experimentation it was found that one-third of an erythema exposure, directed to the testicles caused a disintegration of the spermatozoa and a diminution in their number

Complete sterilization results only from massive doses the so-called castration dose with the 200 000 volt technic being placed at about 40 per cent of the maximum amount tolerated by the skin In the experience of the author it requires a suberythema exposure filtered applied to each of seven ports of entry and repeated at four week intervals two to four times to produce a premature menopause

Before the biological effect of the ray was understood and protective precautions observed many radiologists or their technicians were being constantly exposed to the ray It was found that after from one to five years, numerous operators developed aspermia Later investigation of these cases showed that this condition disappeared in about two years if the work was abandoned or suitable protection used The technical workers of some of the large experimental laboratories are now protected by a special lead and leather garment and although they are exposed to

excessive *amounts of X radiation, they are not made sterile* Ample protection is afforded by the lead rubber apron in common use There is no reason to fear causing sterility unless the testicles or ovaries are to be exposed Where exposures about the pelvis are to be made, suitable X ray protective material should be placed over the ovaries or testicles or, if these organs must be exposed, the patient should be warned of the probable result before the treatment is undertaken

Steiger reports an interesting case treated for uterine fibroid Prior to 1907 the woman had had four children, there were no further pregnancies until 1914, at which time she aborted at the tenth week. In 1916 she was found to have a fibroid, complicated by hyperthyroidism The patient was treated for both of these conditions on June 7 and 21 July 5 and 19, and August 2 She menstruated July 19 and 28, three days each time No further menstruation after September, 1917 Treatment of the thyroid was continued until May, 1918 She became pregnant in September, 1919, and in the latter part of April, 1920, was delivered of a normal child

Pregnancy—Although malformations and monstrosities have been hatched from chickens' eggs that have been exposed to radiation there are no cases in the literature which show any untoward effects *following* radiation during human gestation

Bacteria—It has been found by experimentation that the beta ray is the most destructive to microorganisms, which have been killed at a depth of 2 millimeters below the surface of gelatin media The amount of radiation required is so excessive that in living tissue no direct bactericidal effect can be obtained by therapeutic amounts It is nevertheless true that many skin lesions of recognized bacterial etiology respond favorably to radiation Many theories have been advanced to account for this, such as increased phagocytic action of the blood-cells, production of bacteriolytic enzymes, and one investigator was able to demonstrate an increased opsonic index after radiation Whatever the explanation of this may be, the fact remains that areas radiated do tend to become free from bacteria, as is well illustrated in the treatment of diphtheria-carriers, the cultures from whose throats become negative after one or two exposures

RADIODERMATITIS

Following an X ray exposure there is, as has already been stated an inhibition of all tissues If the amount has been small a return to normal will occur in a short time without any physical manifestations If, however, the exposure has been of sufficient intensity, there will follow, in a period of from a few days to two weeks, an erythema or radiodermatitis This must not be confused with the erythema which frequently appears

in from one to twenty four hours following an exposure and disappears in from twenty four to forty eight hours due, according to Pfahler to electrostatic discharge, and can be prevented by grounding the lead foil protective

Radiodermatitis is of three degrees first second, and third

The *first degree* is characterized by an erythema which appears in from seven to fourteen days, and varies in intensity from a faint blush to a deep red, reaching its maximum in about two weeks, and disappearing in about four weeks It is followed by mild pigmentation or tanning, which may last several weeks or months, gradually disappearing

If the exposure has been on a hairy part an alopecia will result which may be either temporary or permanent This reaction is accompanied by a slight burning or stinging sensation and itching

In *second-degree* radiodermatitis the erythema is apt to appear somewhat earlier than in one of the first degree It is characterized by erythema vesiculation exudation and excoriation, accompanied by a burning stinging sensation which may be severe and distressing Second degree radiodermatitis usually requires several weeks or even two or three months to heal, depending on its severity and the extent of the area involved

In *third-degree* radiodermatitis it is difficult to draw a sharp line of demarcation between a severe second and a mild third It is characterized by all the symptoms of the second degree and in addition there is always an ulceration of the true skin The erythema usually appears in three or four days and as a rule the earlier the appearance of the erythema the greater the severity of the radiodermatitis Almost from its first appearance the erythema is a dusky or even purplish red, and usually there is an ulceration of the skin subcutaneous tissue and there may be an involvement of even the deep muscular tissue and fascia It is accompanied to an exaggerated degree, by all the symptoms of second degree radiodermatitis, and in addition the pain is exceedingly severe

Sequelæ—The *first degree* results in tanning which will disappear as a rule within a few weeks or months following a single exposure If repeated erythemas are produced atrophy will result followed in six months to one year by telangiectasia and permanent alopecia if hairy portions are involved It is an axiom to bear in mind Never produce an erythema especially in an exposed part unless the condition warrants the possibility of subsequent atrophy and telangiectasia that is, in epithelioma lupus vulgaris etc but never in acne tinea tonsurans etc

The *second degree* results in atrophy alopecia telangiectasia, and later keratosis which may degenerate into epithelioma, which is always of the squamous or prickle-cell type

In the *third degree* while there may be healing after a period of a few months with resulting telangiectasia atrophy and keratosis, which

excessive amounts of X radiation, they are not made sterile Ample protection is afforded by the lead rubber apron in common use There is no reason to fear causing sterility unless the testicles or ovaries are to be exposed Where exposures about the pelvis are to be made, suitable X ray protective material should be placed over the ovaries or testicles or, if these organs must be exposed, the patient should be warned of the probable result before the treatment is undertaken

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Idiosyncrasy—Severe reactions occasionally occurring when the exposure apparently has not been excessive, are explained by so called "X ray idiosyncrasy"

As technic improved, untoward results became less frequent, and to day the existence of true idiosyncrasy is denied by the best workers Exposures which produce unexpectedly severe reaction can usually be traced to some error in judgment or inaccuracy in technic

There may be a hypersensitiveness and certain conditions do influence the action of the ray A blond skin is more sensitive than a brunette The flexor surfaces of the body are more sensitive than the extensors Age is a factor children being more susceptible than adults and a young adult more than an aged person Certain drugs enhance the action of the ray and positive information as to the length of time since their last use must be obtained before irradiation is determined upon

One of the most constant sources of danger is inaccuracy of the milliamperemeter a slight variation in its reading being a frequent source of error in exposure To avoid this two milliamperemeters should be used in series If this is impossible the one employed should be tested frequently All factors must be maintained constant during an exposure since a variation in any one means a change in all

The area surrounding the part to be irradiated should be protected, and injury through failure to use this precaution is unjustifiable During exposure the patient must be constantly under observation for any one of the many accidents which might occur may result in the death of the patient unless the operator is prepared for the emergency Accurate records of every detail of the treatment must be kept as in radiotherapy the medicolegal aspect must be constantly borne in mind

The following drugs should never be employed within two weeks preceding during nor two weeks subsequent to the use of X ray In the ordinarily used formulæ they are keratoplastic and in strong solutions they are keratolytic X ray lowers cell vitality in all tissues When this occurs in an area where these drugs have been used this action becomes more powerful and the keratolytic action of the drug follows

Iodin
Iodoform
Resorcin
Oil of Cade
Coal tar Preparations
Lotia Alba
Silver Nitrate
Stronger Mercurial Preparations
Ice

Heat
Musterole
Baume Analgesique
Beta Naphthol
Chrysarobin
Gasoline
Benzin
Turpentine
Scarlet Red
Sulphur

is more likely to degenerate into a prickle-cell epithelioma, the usual result is an indolent ulcer

Treatment—*First Degree* —The first degree usually requires no treatment If the burning or itching is annoying, a lotion of calamine and zinc in witch hazel may be used One or 2 per cent carbolic acid may be added Unguentum aquæ rosæ or vaselin may be all that will be required

Second Degree —If there is no vesiculation, the calamine and zinc may be used, or an ointment containing 1 to 3 per cent ichthyol may be used in combination with zinc oxid

℞
Ichthyol—1 to 3 per cent
Zinc Oxid
Ung Aq Rosæ

To this may be added phenol 1 to 2 per cent, or menthol gr 1 to 3 If vesiculation and exudation are present, a wet dressing is to be preferred, but it must be borne in mind that the exudation (degenerated cell products) is extremely irritating and, wherever it comes into contact with the normal skin, will give rise to an acute eczematous condition. To avoid this, the surrounding normal tissue should be covered with a layer of vaselin before the wet dressing is applied The following dressing, suggested by Dr David Satenstein, will be found of service

℞	*Parts*
Boracic Acid	4
Sodium Chlorid	10
Sodium Bicarbonate	20
Aq q s ad	100
Apply locally	

Third Degree —The most marked symptom of third-degree radiodermatitis is the severe pain, and it is to this that the principal treatment must be directed While local applications may afford some relief, it is frequently necessary to resort to internal medication In mild cases the coal tar products will be sufficient, but in severe ones it may be necessary to resort to morphin or codein These drugs must be used with extreme caution to avoid the danger of drug addiction.

The wet dressing of boracic acid may be used or an ointment containing 5 to 10 per cent of anesthesin will often afford some relief After separation of the slough, the pain becomes less severe At this stage an ointment of ichthyol, 1 to per cent, is indicated

If an indolent ulcer results healing may be produced, or at least aided, by use of the Kromayer or Alpine sunlamp

In extreme cases, or if healing has not taken place in a year it is advisable to excise the entire affected area and skin graft

in the upper scale changing to a yellowish green and that it was difficult to obtain fresh bands, made their use impractical

In 1916 the author, in collaboration with Dr Witherbee conducted a series of experiments to devise if possible a means of measuring X ray dosage by the use of definite factors—spark gap milliamperage, time, and distance—in order to obviate the use of pastille and radiometer The results of the experiments were published in 1917

In measurement of photographic intensities it was shown by Shearer that by doubling the voltage, four times the amount of radiation and that by doubling the distance one-quarter of the amount reaches the plate His formula was as follows

$$\frac{\text{Voltage} \times \text{Voltage} \times \text{Current} \times \text{Time}}{\text{Distance} \times \text{Distance}}$$

For convenience, suppose the following factors are taken

5 Inches Spark Gap (voltage)
20 Milliamperes
4 Minutes
20 Inches Distance
then

$$\frac{5 \times 5 \times 20 \times 4}{20 \times 20} = \frac{2000}{400} = 5$$

If the voltage be doubled the intensity will be increased four times as expressed by the following formula

$$\frac{10 \times 10 \times 20 \times 4}{20 \times 20} = \frac{8000}{400} = 20$$

However when this rule was applied to X ray dosage from the stand point of pastille measurement it was found that doubling the spark gap instead of increasing the intensity four times as would be expected from the roentgenographic formula only doubled it It was further shown that the pastille measurement corresponded to the biological effect on the skin Thus the formula for measurement of unfiltered X ray intensity in radio therapy is

$$\frac{\text{Spark Gap (voltage)} \times \text{Milliamperage} \times \text{Time}}{\text{Distance} \times \text{Distance}}$$

Having established an equation using the factors necessary to produce a certain biological or pastille effect the result could be repeated on dif

Benzoic Acid	Stronger Ammonia Preparations
Balsam of Peru	Chloroform
Mustard	

The action of the following drugs, in connection with X ray, has not been definitely determined, and they should be used with extreme caution

Camphor	Chloral	Menthol

The following drugs may be used

Phenol up to 2 per cent	Zinc Oxid	Icthyol 1 to 3 per cent
Alcohol	Boracic Acid	Calamine
Magnesium Carbonate	Bismuth	Bay Rum
Vaselin	Lanolin	Ether
	Picric Acid	

METHOD OF COMPUTING X RAY INTENSITY OR DOSAGE

Unfiltered Radiation

In radiotherapy it is necessary to establish an accurate method of measurement of the quantity of X ray administered

In 1904 Sabouraud and Noire devised the first practical means of measurement, making use of Villard's discovery that the platinocyanid of barium is colored by exposure to the X ray They found that when exposed to an amount of radiation sufficient to depilate the scalp, the color of this chemical changed to orange They then made a radiometer having a scale of two colors, the first which they called tint 'A," corresponding to the unexposed chemical, and a second, called tint 'B," corresponding to the orange By exposing a fresh pastille of barioplatinocyanid to the X ray and comparing it to the standard scale, the operator was able to determine the so-called erythema exposure

Later, Holzknecht devised his radiometer which was without doubt the best instrument for use with pastilles Utilizing the same principle as Sabouraud and Noire, he established a color scale with finer gradations. Such a scale was necessary in order to give fractional treatment The different shadings were called H 1, H 2, etc, H-4 being the amount necessary to depilate the scalp and H , the equivalent of tint 'B' of Sabouraud and Noire This scale was graduated to H 32, or 8 skin units

The fact that the pastilles made by the various manufacturers were not uniform, that unless carefully preserved they were liable to change color, that the celluloid band or index was not permanent, after a time

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The fact that the pastilles made by the various manufacturers were not uniform, that unless carefully preserved they were liable to change color, that the celluloid band or index was not permanent, after a time

What would be the distance required to produce 1 skin unit, using the following factors 3 inch spark gap 3 milliamperes 16 minutes?

$$\frac{3 \times 3 \times 16}{D \times D} = \frac{144}{D}$$

$$\frac{144}{D} \div \frac{36}{64} = \frac{144}{D} \times \frac{64}{36} = \sqrt{\frac{256}{D}} = 16 \text{ inches (distance)}$$

What would be the amount of radiation produced using the following factors 6 inch gap 3 milliamperes 5 minutes, at 8 inch distance?

$$\frac{6 \times 3 \times 5}{8 \times 8} = \frac{90}{64}$$

$$\frac{90}{64} \div \frac{36}{64} = \frac{90}{64} \times \frac{64}{36} = \frac{5}{2} = 2\tfrac{1}{2} \text{ (skin units)}$$

The following experiment was also done

Experiment Showing Time for One Unit

	Milliamperes	Spark Gap	Distance	Time	Skin Unit
(1)	3	3	8	2	½
(2)	3	6	8	2	1
(3)	6	3	8	2	1
(4)	3	6	16	2	¼

From the above experiments the following rules can be deduced

1 Doubling the spark gap or milliamperage doubles the amount or halves the time

2 Doubling the distance quarters the amount or quadruples the time

Filtered Radiation

According to the pastille measurement twice the amount of radiation, or 2½ skin units is required to produce an erythema when a filter is interposed

In the estimation of filtered intensity or dosage the method differs for while in unfiltered radiation there is one standard formula in filtered there must be a formula for each thickness of filter employed Further divergence from the photographic formula is noted in that the intensity

ferent patients, using the same or different machines It was also found that by using this formula other factors could be substituted and the same results obtained by arithmetical computation, and that three factors being known, the fourth could be computed

In pastille readings with the Holzknecht radiometer H 1 is used as the unit of measurement, and represents one fifth of the amount of radiation necessary to produce an erythema Four times this (H-4) is the amount necessary to depilate the scalp without causing a permanent alopecia, and is the so-called "skin unit"

The standard formula for 1 skin unit, using a 3 inch spark gap, 3 milliamperes, 4 minute time, at 8 inch distance, is

$$\frac{3 \times 3 \times 4}{8 \times 8} = \frac{36}{64}$$

Any or all factors may be changed, and given any three factors the fourth may be obtained by the following rules

1 To determine milliamperage, spark gap, or time, the standard formula is used as the dividend

2 To determine distance or amount the standard formula is used as the divisor

Examples

What would be the time necessary for one unit, using a 6 inch gap, 3 milliamperes, and 8 inch distance?

$$\frac{6 \times 3 \times ?}{8 \times 8} = \frac{18}{64}$$

$$\frac{36}{64} - \frac{18}{64} = \frac{36}{64} \times \frac{64}{18} = 2 \text{ (minutes time needed)}$$

It therefore follows that if the spark gap be doubled, and the time reduced one half, the same amount of radiation will be produced

What spark gap would be necessary to produce 1 skin unit using the following factors 3 milliamperes, 2 minutes, 8 inch distance?

$$\frac{? \times 3 \times 2}{8 \times 8} = \frac{6}{64}$$

$$\frac{36}{64} - \frac{6}{64} = \frac{36}{64} \times \frac{64}{6} = 6 \text{ inches (spark gap required)}$$

What would be the distance required to produce 1 skin unit, using the following factors 3 inch spark gap 3 milliamperes 16 minutes?

$$\frac{3 \times 3 \times 16}{D \times D} = \frac{144}{D}$$

$$\frac{144}{D} \quad \frac{36}{64} = \frac{144}{D} \times \frac{64}{36} = \sqrt{\frac{256}{D}} = 16 \text{ inches (distance)}$$

What would be the amount of radiation produced using the following factors 6 inch gap, 3 milliamperes 5 minutes at 8 inch distance?

$$\frac{6 \times 3 \times 5}{8 \times 8} = \frac{90}{64}$$

$$\frac{90}{64} \quad \frac{36}{64} = \frac{90}{64} \times \frac{64}{36} = \frac{5}{2} = 2\tfrac{1}{2} \text{ (skin units)}$$

The following experiment was also done

EXPERIMENT SHOWING TIME FOR ONE UNIT

	Milliampere	Spark Gap	Distance	Time	Skin Unit
(1)	3	3	8	[illegible]	½
(2)	3	6	8	[illegible]	1
(3)	6	3	8	[illegible]	1
(4)	3	6	16	[illegible]	¼

From the above experiments the following rules can be deduced

1 Doubling the spark gap or milliamperage doubles the amount or halves the time

2 Doubling the distance quarters the amount or quadruples the time

FILTERED RADIATION

According to the pastille measurement twice the amount of radiation or 2½ skin units is required to produce an erythema when a filter is interposed

In the estimation of filtered intensity or dosage the method differs for while in unfiltered radiation there is one standard formula in filtered there must be a formula for each thickness of filter employed Further divergence from the photographic formula is noted in that the intensity

varies inversely with the distance instead of with the square of the distance

Also the time factor in filtered radiation differs from that of unfiltered in its action on the skin and pastille, for while in the latter doubling the time doubles the amount, in filtered radiation the increase in the pastille reading depends on the spark gap or voltage in connection with the filter employed When a 6 inch spark gap is used and the time required for 1 filtered unit is doubled, the reading is 1¼ filtered units instead of 2 Repeating this process advances the reading ¼ filtered unit When a 7 inch gap is employed, doubling the time produces 1½ filtered units, and the reading then advances at the rate of ¼ filtered unit for each exposure Using an 8, 9 or 10 inch gap advances the reading at the rate of ½ for each exposure until 2 filtered units have been reached, and then advances at the rate of ¼ filtered unit

The only exception to this rule is where 5, 6, or 7 millimeters of aluminum are used when doubling the time advances the reading to 2, and then at the rate of ½ for each exposure up to 3 filtered units

The following formulæ have been established for the different thicknesses of aluminum filter employed The thickness of these filters ranges from ¼ to 7 millimeters

FORMULÆ FOR ALUMINUM FILTER

Millimeters of Aluminum	Spark Gap	Milliamperes	Distance Inch	Time	Standard Formula
¼	9	5	10	0 min 42 sec	$\frac{63}{20}$
½	9	5	10	1 " 06 "	$\frac{99}{20}$
1	9	5	10	1 " 54 "	$\frac{171}{20}$
2	9	5	10	2 " 20 "	$\frac{91}{2}$
3	9	5	10	2 " 24 "	$\frac{231}{20}$
4	9	5	10	4	18
5	9	5	10	7 "	$\frac{63}{2}$
6	9	5	10	7 "	$\frac{63}{2}$
7	9	5	10	7 "	$\frac{63}{2}$

This fact has been disputed and is still a matter of contention between the physicists and the author of this paper *While from the physicists point of view* their contention based on the action of the ray on the photographic plate and the ionization chamber is correct from the biological standpoint and the experience gained by the use of the formula for the past six years by many radiotherapeutists its correctness up to 110 000 volts and 7 millimeters of aluminum has been fully *established*

To illustrate the difference in reading when the time necessary to produce one filtered unit is increased, the following table from Witherbee and Remer's original article is copied—in each instance the filter being 3 millimeters aluminum

DIFFERENCES IN READING SHOWN

Spark Gap	Milliamp	Dist	Time	Filtered Unit
6	5	10	3 min 51 sec	1
6	5	10	7 min 42 sec	1¼
6	5	10	11 min 33 sec	1½
6	5	10	15 min 24 sec.	1¾
6	5	10	19 min 15 sec	2
7	5	10	3 min 18 sec	1
7	5	10	6 min 56 sec	1½
7	5	10	9 min 54 sec	1¾
7	5	10	13 min 12 sec	2
7	5	10	16 min 0 sec	2¼
7	5	10	19 min 48 sec	2½
7	5	10	23 min 6 sec	2¾
7	5	10	26 min 28 sec	3
8	5	10	2 min 53 sec	1
8	5	10	5 min 46 sec	1½
8	5	10	8 min 9 sec	2
8	5	10	11 min 32 sec	2¼
8	5	10	14 min 25 sec	2½
8	5	10	17 min 18 sec	2¾
8	5	10	20 min 11 sec	3
9	5	10	2 min 34 sec	1
9	5	10	5 min 8 sec	1½
9	5	10	7 min 4[illegible] sec	2
9	5	10	10 min 16 sec	2¼
9	5	10	12 min 50 sec	2½
9	5	10	15 min 24 sec	2¾
9	5	10	17 min 58 sec	3
10	5	10	2 min 19 sec	1
10	5	10	4 min 58 sec	1½
10	5	10	6 min 5 sec	2
10	5	10	9 min 16 sec	2¼

The mathematical computation for filtered radiation differs somewhat from that of unfiltered in that it is always necessary first to find the time required for 1 filtered unit, and this must be multiplied by the number of times this exposure must be repeated to obtain the desired amount

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6	5	10	19 min 15 sec	2
7	5	10	3 min 18 sec	1
7	5	10	6 min 36 sec	1½
7	5	10	9 min 54 sec	1¾
7	5	10	13 min 12 sec	2
7	5	10	16 min 30 sec	2¼
7	5	10	19 min 48 sec	2½
7	5	10	23 min 6 sec	2¾
7	5	10	26 min 28 sec	3
8	5	10	2 min 53 sec	1
8	5	10	5 min 46 sec	1½
8	5	10	8 min [illegible] sec	2
8	5	10	11 min 32 sec	2¼
8	5	10	14 min 25 sec	2½
8	5	10	17 min 18 sec	2¾
8	5	10	20 min 11 sec	3
9	5	10	2 min 34 sec	1
9	5	10	5 min 8 sec	1½
9	5	10	7 min 42 sec	2
9	5	10	10 min 16 sec	2¼
9	5	10	12 min 50 sec	2½
9	5	10	15 min 24 sec	2¾
9	5	10	17 min 58 sec	3
10	5	10	2 min 19 sec	1
10	5	10	4 min 38 sec	1½
10	5	10	6 min 57 sec	2
10		10	9 min 16 sec	2¼

The mathematical computation for filtered radiation differs somewhat from that of unfiltered in that it is always necessary first to find the time required for 1 filtered unit and this must be multiplied by the number of times this exposure must be repeated to obtain the desired amount

Examples

What would be the time required to give an exposure of 2 filtered units using the following factors 7 inch spark gap, 4 milliamperes, 12 inch distance, 1 millimeter aluminum filter

$$\frac{7 \times 4}{12} = \frac{28}{12}$$

The standard formula for 1 millimeter of aluminum is $\frac{171}{20}$

First find the time required by dividing the standard formula by $\frac{28}{12}$

$\frac{171}{20} \div \frac{28}{12} = \frac{171}{20} \times \frac{12}{28} = 3\frac{2}{3}$, or 3 minutes and 40 seconds, time required for one filtered unit

Referring to the above table we find that 4 times this amount is necessary to produce 2 filtered units, therefore 14 minutes and 40 seconds is the required exposure

Unfiltered Treatment—In dermatology the X ray has long been a routine measure, and it was in this branch of medicine that it had its first principal application In some instances it is curative where other methods have failed In others, it is a valuable adjunct to medication

The advantage of cleanliness, convenience, and absence of pain, and the elimination of the use of irritating and offensive ointments, usually commend it to the patient "Often there are economic reasons which make its use more practical especially for the wage-earner"

The method used in dermatological work is that of unfiltered radiation A spark gap of 6 to 7 inches, a current of 2 to 5 milliamperes, with a target skin distance of 8 inches, usually gives the best results The time and number of exposures must of necessity vary with the nature of the condition under treatment—from one-tenth of an erythema exposure, when the pathological condition is of an acute or subacute inflammatory nature to two or more erythema exposures, when it is of the granulomatous or neoplastic type

The methods employed in the treatment are the intensive, the semi-intensive, and the fractional

Intensive Treatment—Single exposures of from 1 to $2\frac{1}{2}$ skin units repeated at four to six week intervals

Semi-intensive Treatment—Exposures of from $\frac{1}{2}$ to $\frac{3}{4}$ skin unit repeated every two or three weeks

Fractional Treatment—$\frac{1}{8}$ to $\frac{1}{4}$ of a skin unit repeated semiweekly if the $\frac{1}{8}$ S U is employed, and weekly if the $\frac{1}{4}$ S U is used

Not only is there a pathological indication for the intensity of exposure, but there is also a technical condition, that is, the character of the

skin, the age of the patient, etc. Also, the entire body should not be exposed at one time, owing to too great a systemic reaction, acidosis and too great a reduction of the lymphocytes to insure a normal recovery before the time of subsequent exposure.

In generalized conditions such as psoriasis, generalized eczema and mycosis fungoides exposures are preferably given three times a week, allowing a day to elapse between each exposure. The entire body is divided into three areas and these again subdivided. For the first exposure the head and arms are radiated, second the trunk and buttocks and third the legs and thighs.

The head is divided into five areas as in the Adamson-Kienbock method for tinea of the scalp, the arms, forearms and hands into six areas each, three flexor and three extensor, the trunk into eight areas, four ventral and four dorsal, the buttocks one for each buttock, the legs and thighs into six areas, three anterior and three posterior.

The exposure given is $\frac{1}{4}$ skin unit to each area of the scalp once a week until four exposures have been given. Treatment is then discontinued for four weeks and if necessary a second series is given and after a rest period of four weeks may be repeated if the condition requires.

To each of the areas of the body $\frac{1}{4}$ skin unit is given each week until the lesions have disappeared, the treatment usually being concluded in from four to eight weeks, depending on the severity of the case. If it is impossible to follow the above method, which is the ideal one, the body is divided into two general areas and exposures made twice a week, employing $\frac{1}{8}$ skin unit for each area of the body instead of $\frac{1}{4}$.

When Unfiltered Radiation May Be Used

Rosacea Per Se.—This does not respond to radiation, although the acne which is usually an accompaniment of this condition will be benefited.

Lichen Planus.—Favorable results are practically always obtained in the treatment of lichen planus by irradiation, but on the character of the lesions will depend the technic to be employed. The influence of the ray on the severe pruritus which accompanies this condition is marked frequently after the first treatment.

When the disease is generalized, the technic given for generalized diseases should be followed. In the acute or chronic type $\frac{1}{4}$ skin unit at weekly intervals should be administered. Usually involution begins after one or two exposures and a cure is effected after from 6 to 10 irradiations. In the hypertrophic type of the disease the $\frac{1}{4}$ skin unit is not sufficient to bring about the desired result, so that a suberythema exposure of 1 skin unit is best employed, to be repeated every four weeks.

Small circumscribed patches of ordinary lichen planus respond to frac

tional doses of 1/4 skin unit administered weekly, the individual lesions being isolated, and the surrounding normal skin protected with lead rubber or lead foil

In the verrucous type, owing to the marked hyperkeratosis intensive treatment should be given 1 1/4 to 1 1/2 skin units should be administered and repeated in four to five weeks, if necessary Care must be taken to protect fully the surrounding normal skin with lead foil While usually unfiltered ray is effectual in the verrucous type, involution may frequently be hastened by using a filter of 1 millimeter aluminum, an exposure of 2 filtered units being given

Psoriasis—It is doubtful if there is any method of treatment that can compare in favorable results with X ray in the treatment of psoriasis The cleanliness of the method as compared with the use of ointment, especially chrysarobin, appeals to the patient, and also from an economic standpoint it is of value, but it must be borne in mind that the disease is incurable and that recurrences are bound to appear sooner or later, the time varying from a few weeks to a year In one case in the author's practice there was no recurrence for two years

Occasionally there are cases which will not respond to radiation new lesions appearing in areas which have shown improvement, and are under treatment In a case where the disease is to be influenced by radiation, it will disappear under 6 to 8 treatments of fractional exposures of 1/4 skin unit given weekly, an improvement being noted after two or three exposures If the disease shows no improvement after 8 to 10 irradiations it is well to discontinue the X ray treatment

When the disease is general, the method suggested for generalized diseases should be followed Should the scalp be involved, no more than a total of 1/2 skin unit, divided into weekly exposures of 1/8 skin unit each, should be given One course should be sufficient to cure, but if not there should be an intermission of four weeks, after which the treatment may be repeated The five points used in tinea tonsurans are used in treating the scalp although accurate measurements are not made

If the lesions are of long standing and there is much thickening, good results may often be obtained by the use of 1 millimeter of aluminum filter, 1/2 filtered unit being administered every one or two weeks

Recurrences—While it is permissible to treat recurrences in the manner above outlined judgment must be exercised in the use of the ray, and it must be borne in mind that too prolonged radiation, even in fractional doses, may cause atrophy of the skin and underlying tissues, which will be followed by telangiectasis

Psoriasis of Face—The same technic should be followed in this condition as in acne of the face Psoriasis of the hands and feet yields to the same technic as psoriasis of other parts of the body It is often necessary to expose both the dorsal and palmar surfaces If both hands

are affected, it is best to irradiate each hand separately and, in exposing the palmar surface, to measure from the highest point, that is, the thenar eminence. Each foot should also be exposed separately.

Psoriasis of Nails.—This condition is more resistant to irradiation, and frequently ten or twelve treatments are necessary to produce satisfactory results. The skin about the nails should be protected, as in paronychia or similar nail conditions.

Eczema.—Probably in no dermatological condition has X-ray a wider therapeutic range or greater value than in eczema, both in the acute and chronic types. As early as 1900 it was used with beneficial results, but with the more definite knowledge of the conditions which are now classed under the general heading of eczema its use and application have become more general and efficacious.

In the earlier history of the X-ray for this condition it was thought that permanent clinical cures could be effected, but this has been found to be erroneous. There are apt to be recurrences, the time of recurrence varying with the different causes and types of the disease.

The response of eczema to the ray is usually very prompt, frequently being manifest after the first or second exposure. Among the early symptoms to be relieved is the intense pruritus.

The intensity of the exposure of Roentgen ray in the therapy of eczema depends upon the principle that the more acute the inflammatory process the less the intensity of exposure required, and, conversely, the more chronic the process, that is, the types associated with thickening, namely, acanthosis and connective tissue hypertrophy or hyperplasia, the greater the intensity required to cause absorption.

Technic.—When the condition is generalized the body should be divided into areas and treated as previously described. When the lesions are isolated each lesion should be treated individually, the surrounding healthy skin being protected by lead. For mild acute or subacute types, exposures of from 1/8 to 1/4 unfiltered skin unit should be made every three to seven days. For the more chronic types, exposures of from 1/2 to 3/4 of an unfiltered skin unit should be administered every two or three weeks.

Frequently in the use of the unfiltered ray, especially in the indurated types, absorption will be slow. The prolonged use of the X-ray which may be necessary, may produce atrophy and subsequent telangiectasia. In such cases the use of filtered exposures is indicated, the amount of thickening and the penetration of the ray desired determining the thickness of the filter to be employed, that is, from 1 to 3 millimeters of aluminum. The exposure should be 1/2 to 1 filtered unit administered every seven to fourteen days. In the mild acute and subacute types, from six to ten exposures will usually produce a clinical cure; in the more chronic types, especially where there is much thickening, a longer time usually will be required.

The intensity of the exposures and the intervals between the exposures whether filtered or unfiltered, will depend upon the clinical status of each individual case

The employment of X ray in eczema does not by any means prohibit the use of drugs which may be of value in connection with the ray, such as zinc, boric acid, calamine, bismuth mild preparations of ammoniated mercury etc (see complete list of permissible and contra indicated drugs) in the form of powder, lotions, pastes or creams, as indicated

Lupus Vulgaris—Although opinions differ regarding the results obtained in the treatment of lupus vulgaris by irradiation, in properly selected cases its value cannot be overestimated In the atrophic type of the disease the ray has little or no effect Not only will satisfactory results not be obtained, *but the prolonged treatment that is necessary* will result in injury to the skin and underlying tissues It is in the hypertrophic and ulcerative type that X ray is applicable, and in these types the results will prove not only beneficial, but highly gratifying

Technic—The intensive or suberythema method should be employed rather than the fractional, and, as the disease occurs at all ages and affects various parts of the body, on the age of the patient and location of the lesions must depend the intensity of the exposure From ½ skin unit in children to from 1 to 1¾ skin units in the case of adults should be administered and repeated at intervals of from four to five weeks It is wise to begin with exposures of lesser intensity (½ to 1 skin unit) and, if not followed by improvement, to increase the amount of radiation An erythema should be avoided if possible, particularly when the lesion is situated on the face However, if the condition does not respond to suberythema exposures, the disease warrants producing an erythema, even though a subsequent atrophy and telangiectasia may result In irradiating it is important to expose beyond the border of the lesion so that from ¼ to ½ inch of normal skin is included in the field irradiated The surrounding normal skin should be protected by lead There may be recurrences and these should be treated in the same manner as the original condition

Lupus Erythematosus—Irradiation in this disease is unsatisfactory and is not advised While in the early inflammatory stage, beneficial results may be obtained, later there is an "end result" of a chronic inflammatory process, with atrophy and telangiectasia If treatment is undertaken, the fractional method of ¼ skin unit at weekly intervals should be employed and if after four or five treatments there is no improvement, a change of technic is advised, administering from 1 to 1¼ skin units every four to five weeks

Mycosis Fungoides—Although mycosis fungoides is incurable marked relief can be afforded, a temporary clinical cure effected, and the life of the patient prolonged by X ray There will always be recurrences

and the disease will ultimately prove fatal One of the marked symptoms the almost intolerable pruritus can be controlled and is among the first symptoms affected Mycosis fungoides presents its own indication for the frequency and intensity of the exposures When the disease is generalized, particular caution must be exercised in the treatment as the disease seems to be extremely sensitive to X ray and the patient particularly susceptible to systemic reaction

Technic—In undertaking the treatment it is well to begin with exposures of small intensity and if well tolerated to increase the amount after two or three exposures have been administered In the pretungoid, non infiltrated stage especially if the condition is widespread it is best to begin with exposures of $1/8$ skin unit repeated at weekly intervals After three or four weeks this may be increased to $1/4$ skin unit weekly Too prolonged radiation should not be given as an immunity may be established In such a case an interval of rest should be allowed after which treatment may be resumed with beneficial effect If the disease is not generalized but consists of only isolated non infiltrated plaques, the plaques should be irradiated individually the surrounding healthy skin being protected, and the same intensity of exposure being employed as when the disease is generalized

MacKee advises a differential blood count every two weeks and if there is an increase in the lymphocytes or if there is any evidence of toxemia, that irradiation be temporarily discontinued

In the fungoid stage of the disease fractional treatment will not suffice, and suberythema exposures of 1 skin unit every four weeks should be administered If, after the first irradiation there is not marked improvement the intensity may be increased to $1\frac{1}{2}$ to $1\frac{3}{4}$ skin units repeated when the erythema has subsided Although generally responding to unfiltered radiation, occasionally better results can be obtained by the use of a filter especially if the tumor has attained a considerable size Using a filter of 3 millimeters of aluminum an exposure of from $1\frac{1}{2}$ to 2 filtered units should be administered and repeated in four weeks, if necessary

In severe cases and in the late stages of the disease when the condition may be regarded as systemic Jadassohn advises the following technic The body is divided into six areas and using an 8 inch spark gap, 5 milliamperes and a filter of 3 millimeters of aluminum $\frac{1}{2}$ filtered unit is administered each day for six days one area being irradiated at each exposure A rest period of four days is then allowed following which a second series of irradiations is given again followed by a rest period of four days and a subsequent third series of treatments Jadassohn claims for this method that not only is there no deleterious systemic reaction, but on the contrary there is an appreciable improvement in the disease itself and in the general health of the patient.

The intensity of the exposures and the intervals between the exposures, whether filtered or unfiltered, will depend upon the clinical status of each individual case

The employment of X ray in eczema does not by any means prohibit the use of drugs which may be of value in connection with the ray, such as zinc, boric acid calamine, bismuth, mild preparations of ammoniated mercury etc (see complete list of permissible and contra indicated drugs) in the form of powder lotions, pastes or creams, as indicated

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In severe cases, and in the late stages of the disease, when the condition may be regarded as systemic Jadassohn advises the following technic The body is divided into six areas and using an 8 inch spark gap, 5 milliamperes, and a filter of 3 millimeters of aluminum ½ filtered unit is administered each day for six days one area being irradiated at each exposure A rest period of four days is then allowed following which a second series of irradiations is given again followed by a rest period of four days and a subsequent third series of treatments Jadassohn claims for this method that not only is there no deleterious systemic reaction but on the contrary there is an appreciable improvement in the disease itself and in the general health of the patient

Tinea Tonsurans and Favus.—No other method is as prompt and efficacious in the treatment of this common and disagreeable condition as is *radiation.* In crowded cities, where a large number of children are affected, the disease becomes not only a nuisance, but also an economic problem. Unless a complete depilation is accomplished, a cure without recurrence cannot be expected. In many instances, but one or two isolated patches may be found, but even in these it is imperative to depilate the *entire scalp, for if only the single patches are treated, the falling hair will affect healthy areas, and ultimately a complete depilation will be necessary.*

By employing the Adamson-Kienbock method of measurement of the scalp and using the Coolidge tube and interrupterless transformer, *an entire scalp can be depilated in from three-quarters to one hour.*

Tinea.—A marker for the measurement of the scalp has been devised by Dr. George Andrews, which permits of accurate measurement with a marked saving of time. While in the hands of a competent operator this method of treatment is simple, and the results accomplished are gratifying, *a word of warning should be sounded, for unless there is absolute accuracy* in every detail, there is great danger of permanent alopecia, if not more serious results.

Before irradiation it is most important to ascertain whether or not the patient has had any previous application of the ray to the scalp, or has been using any irritating drugs, such as salicylic acid, iodin, mercury, etc. If any such drug has been used, it is best to delay treatment for at least two weeks after the last application, as failure to do this may result in a radiodermatitis, or permanent alopecia. It must also be remembered that no irritating application should be used for two weeks following the treatment.

It is inadvisable to attempt to administer treatment to a child under four or five years of age, owing to the difficulty of keeping it quiet. There are, of course, exceptions, as often younger children can be irradiated successfully.

The hair should be clipped close. This not only permits of easier marking, but allows the full amount of ray administered to reach the scalp. (The hair, if thick, filters out a definite amount of ray.) Also, all scabs and crusts should be softened and removed with vaselin or a non-irritating soap and water.

Technic. Marking.—Measure from the anterior to the posterior hair line, subtract 10, divide the remainder by 2. *The quotient will give the* number of inches inside the anterior and posterior hair lines, that is, the frontal and occipital points, and the measurement between these two points should be 10 inches. A point midway between these in the median line will mark the crown point. Measure downward from the crown point 5 inches *on each side for the parietal point.* There then should be exactly

5 inches between all points The circumference of the head should measure 20 inches

For example, suppose the distance from hair line to hair line is 14 inches Subtract 10, which leaves 4 Divide this by 2, which gives 2 inches the distance from the anterior and posterior hair lines The frontal point will be 2 inches posterior to the anterior hair line and the occipital point 2 inches anterior to the posterior hair line The distance between these two will be 10 inches The marker above referred to obviates the necessity of making these measurements

In some cases the distance from hair line to hair line will be found to be exactly 10 inches In such an event the anterior and posterior hair lines will coincide with the frontal and occipital points

Again it occasionally happens that the circumference of the head will measure 19 or 21 inches In such cases 1/4 inch should be added or subtracted from the 5 inches between points

Lines are drawn joining each point, which will divide the scalp into four triangles This will be found of great advantage in determining the angle for each point of exposure, which must be at right angles to every other point

Exposure—Having determined the exact points the procedure is as follows with the child lying on the back, the head is turned to one side so that the line of the chin is on a level with the shoulder The face below the hair line is covered with lead foil An epilating exposure is given to the parietal point The head is then turned to the other side and the opposite parietal point is exposed Lying with the face upward and shielded with lead foil the frontal point is next exposed Then with the child lying on the abdomen and resting on the chin the crown point is exposed The head is then tilted forward so that it rests on the forehead and the occipital point is irradiated Lead foil is placed over the back below the hair line

Although various distances and other factors are used the following used at the Vanderbilt Clinic will be found convenient spark gap 6 inches 3 milliamperes, 6½ inch distance and 1½ minutes time This will give 1 skin unit, an exposure sufficient for epilation

At approximately the end of the third week the hair will begin to fall and the scalp will be depilated at the end of the month The hair will begin to grow again in from one to two months In from four to five months it will have entirely returned If there is not a new growth of hair at the end of six months there will be permanent alopecia

After a scalp has received treatment it is well to wash the head three or four times a week with soap and water, and, when the hair has fallen, to use a mild parasitic ointment A linen cap should be worn during the time defluvium occurs

All fallen hair should be burned to prevent infection of others

Recurrence is unusual, but if there should be a reinfection, a second depilation should not be done for at least five or six months

Favus.—This condition is more resistant, and it is frequently necessary to depilate a second, or even a third, time before a complete cure is effected. The same technic is employed as in tinea tonsurans.

Blastomycosis and Actinomycosis.—Irradiation probably is superior to any other form of treatment for both these rather uncommon conditions. Where the lesions are situated on the skin, unfiltered radiation will give sufficient penetration to eradicate the condition, but if the deeper tissues are involved, better results will doubtless be obtained if a filter of aluminum of from 1 to 3 millimeters is used, depending upon the depth of the lesion beneath the surface.

In superficial lesions from one to three intensive exposures of $1\frac{1}{2}$ to 2 skin units are given at intervals of from four to six weeks. Not infrequently a single treatment is sufficient to cause disappearance of the disease, but even in such a case, a second exposure is advisable as a prophylactic measure.

In the treatment of lesions situated in the deeper structures, 2 to $2\frac{1}{4}$ *filtered units should be administered*.

Pruritus.—The antipruritic action of the X-ray is often remarkable in dermatological conditions. This is especially true in the pruritus of eczema, psoriasis, and lichen planus, the severe itching often being relieved before any manifestation of involution of the disease. This may be, or probably is, due to the effect on the terminal nerve filaments.

Pruritus Ani et Vulvæ.—Satisfactory and even brilliant results are obtained by irradiation, and in practically every case at least temporary relief can be obtained. This relief will last from a few months to a year or more, and in a proportion of the cases will be permanent after one course of radiation. Treatment should not be instituted until all possible causes have been investigated and eliminated. When the anus is the only site of pruritus, the patient should lie on the abdomen holding the buttocks apart with the hands. If, for any reason this is impossible, adhesive strips may be used. When both the anus and vulva or scrotum are involved, the patient lies on the back, the knees and thighs flexed. In women, the region is divided into two areas, and two exposures are made, first centering the tube at the anterior part of the vulva, and then centering it at the anus. The thighs and portions not being exposed should be protected with lead foil.

If the scrotum is involved, it will be necessary to ray the anterior and posterior surfaces separately. To expose the anterior surface, the scrotum is allowed to rest on a sandbag placed between the thighs, the penis being held on the abdomen. Lead foil is used to protect all surrounding skin not being irradiated. In irradiating the scrotum, care

must be exercised to avoid, if possible, producing a temporary sterility.

There are two methods of treatment, fractional and intensive. If the latter is employed, 1 skin unit should be given every four weeks. It is neither necessary nor advisable to produce an erythema. This method is not advised, and better results are usually obtained by the fractional method of treatment. One-quarter skin unit is given weekly until a total of 2 skin units has been given, if a satisfactory result has not been obtained before. The author has obtained the best results by the following method.

The first week an exposure of 1/2 skin unit is given; the second week 3/4 skin unit; and for the third, and subsequent exposures, 1/4 skin unit, given weekly until a total of 2 skin units has been administered. If at the end of six treatments no improvement has taken place, it is best to discontinue the treatment by X-ray.

Recurrences should be treated in the same manner as the original condition.

Keloid.—The results obtained in the treatment of keloid by X-ray are in most instances very gratifying. The earlier the treatment can be instituted after the development of the keloid, the more satisfactory will be the result, and the less treatment required.

In organized and thickened scars, the treatment is necessarily of long duration, sometimes a year being required if a good cosmetic result is to be obtained. In irradiating this condition it is important that an erythema should never be produced.

Technic.—The normal skin must be protected to the very edge of the keloid. On beginning the treatment it is advantageous to cut from lead foil a pattern outlining the lesion. This is kept for the individual case, and affords a means of accurate measurement of the improvement.

Where the condition is recent, unfiltered ray is used, and a suberythema exposure of 1 skin unit is administered every four or five weeks. When the condition is of long standing, or is fibrous in character, a filter of from 1 to 3 millimeters of aluminum may be used to advantage, and an exposure of from 1¼ to 1½ filtered units administered every four to five weeks.

In the negro it is particularly important that no more than a suberythema exposure be given, as repeated erythemas are likely to result in depigmentation.

Dermatitis Papillaris Capillitii or Acne Keloid.—In the earlier or papular stage, unfiltered ray may be employed and the disease aborted, suberythema exposures of 1 skin unit being given every four weeks.

In the later stages, where the keloidal condition has developed, better results will be obtained by employing a filter, the technic being the same as for keloid.

Recurrence is unusual, but if there should be a reinfection, a second depilation should not be done for at least five or six months

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If the scrotum is involved it will be necessary to ray the anterior and posterior surfaces separately To expose the anterior surface the scrotum is allowed to rest on a sandbag placed between the thighs, the penis being held on the abdomen Lead foil is used to protect all surrounding skin not being irradiated In irradiating the scrotum, care

four treatments of filtered radiation, the treatment being instituted immediately after electrocoagulation or operation

It is best to expose three small areas on each side of the jaw, extending from the symphysis mentis to beyond the ramus of the mandible to $1\frac{3}{4}$ to 2 filtered units every four weeks for three or four exposures This is imperative if there is evidence of glandular involvement

Melanoma—This condition can usually be caused to disappear after three or four intensive treatments with unfiltered radiation If, after the fourth treatment, the condition persists other means should be employed

It has been the author's custom to apply the ray to three concentric areas having the lesion as their common center In order to accomplish this without danger of overlapping, three pieces of lead foil at least 6 inches square are used In the first of these is made an opening just large enough to include the lesion In the second the opening is made to include the lesion and half an inch of the surrounding healthy tissue In the third the opening should be made large enough to include the lesion and 1 inch or more of the surrounding tissue The piece with the largest portal is first placed so that the lesion is at its center, and an exposure of 1 skin unit is given All tissue except that in the area being treated should be covered by lead foil The medium sized portal is next placed around the lesion and from $\frac{1}{2}$ to $\frac{3}{4}$ skin unit given The smallest portal is then placed so as to expose only the lesion and $\frac{1}{2}$ to $\frac{3}{4}$ skin unit is administered

In this way the lesion receives from 2 to $2\frac{1}{2}$ skin units the amount given depending on the location of the lesion and the age of the patient

A second treatment is administered after the erythema has subsided, which will be at the end of five or six weeks and a third and fourth exposure after like intervals The patient should then report for observation every month or two for one year and further treatment be given if any tendency toward recurrence is noted

Acne—Probably there is no condition which responds more favorably to X ray treatment nor in which more absolute technic is required than acne One must bear in mind however the danger of overexposure either in excessive individual exposures or in prolonging the treatment to an excessive number of exposures Properly selected cases with accurate application of the ray and proper constitutional treatment will result in a cure in about 95 per cent of the cases The fractional method is employed

Technic—The patient is placed in the prone position with lead foil protecting the eyebrows eyelashes and hair The head is turned to the side, the chin being placed as nearly as possible on a line with the shoulder With the anode centered over the highest point (usually the zygoma), exposures of $\frac{1}{4}$ skin unit are given at weekly intervals to each side of the face and if there are numerous active lesions of the chin and fore-

Epithelioma—In the basal cell type of epithelioma, cures are effected in about 95 per cent of the cases, and recurrences are rare if the amount of radiation has been adequate

Technic—Curettage of the growth before radiation is advisable in order to remove the hard pearly border which is usually present, as the *removal of this permits the ray to penetrate* more deeply and more effectively The area is covered with a piece of lead foil in which an opening has been made sufficient to expose the lesion and from 1/4 to 1/2 inch of the normal surrounding tissue This is necessary in order to affect the cells which may lie beyond the periphery of the lesion The area is given 2 to 2 1/2 skin units After ten days an erythema appears, which lasts from ten days to two weeks and gradually disappears, the time depending upon the severity of the erythema The appearance of the erythema is an indication of the inhibition of the tissue exposed. As soon as the erythema has subsided, which is an indication of the recovery of normal tissue elements (usually in from four to six weeks) a second exposure is given If all evidence of the disease has disappeared, the second exposure should be of less intensity than the first, that is from 1 1/2 to 1 3/4 skin units If, however, *there is still evidence* of disease, the second exposure should be of the same intensity as the first This usually is sufficient to effect a cure Care must be exercised in the treatment of this condition, as too frequent or prolonged radiation will so inhibit the normal tissue as well as the pathological, that a chronic third degree radiodermatitis will result If after a third or fourth irradiation a cure has not been obtained, it is best to employ some other means of treatment

The patient should be kept under observation for a year, and *further* treatment administered if there is any sign of recurrence

Prickle cell or Squamous cell Epithelioma—This condition may occur on the skin, mucous membrane, or mucocutaneous junction If this type is recognized in the early stage, it may yield to radiation if promptly and intensively treated, but on account of its tendency to metastasize, if not diagnosed and irradiated early, the neighboring glands may have become affected

The technic of this treatment is the same as that outlined for the basal cell type except that lesions on the vermilion border should be exposed *to only 1 3/4 to 2 units, since the mucosa is more easily* affected than is the skin

Unless there is marked improvement after the first treatment, surgery or electrocoagulation should be employed This is especially true of lesions of the vermilion border, which are apt to be particularly difficult to control, and which from the arrangement of the lymphatics, show early metastasis to the submaxillary glands

Whether *the lesion be treated by electrocoagulation or surgery* it is wise to expose the affected area and the submaxillary region to three or

four treatments of filtered radiation the treatment being instituted immediately after electrocoagulation or operation

It is best to expose three small areas on each side of the jaw, extending from the symphysis mentis to beyond the ramus of the mandible to 1¾ to 2 filtered units every four weeks for three or four exposures This is imperative if there is evidence of glandular involvement

Melanoma—This condition can usually be caused to disappear after three or four intensive treatments with unfiltered radiation If after the fourth treatment the condition persists, other means should be employed

It has been the author's custom to apply the ray to three concentric areas having the lesion as their common center In order to accomplish this without danger of overlapping three pieces of lead foil at least 6 inches square are used In the first of these is made an opening just large enough to include the lesion In the second, the opening is made to include the lesion and half an inch of the surrounding healthy tissue In the third the opening should be made large enough to include the lesion and 1 inch or more of the surrounding tissue The piece with the largest portal is first placed so that the lesion is at its center and an exposure of 1 skin unit is given All tissue except that in the area being treated should be covered by lead foil The medium sized portal is next placed around the lesion, and from ½ to ¾ skin unit given The smallest portal is then placed so as to expose only the lesion and ½ to ¾ skin unit is administered

In this way the lesion receives from 2 to 2½ skin units, the amount given depending on the location of the lesion and the age of the patient

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Technic—The patient is placed in the prone position with lead foil protecting the eyebrows, eyelashes, and hair The head is turned to the side, the chin being placed as nearly as possible on a line with the shoulder With the anode centered over the highest point (usually the zygoma), exposures of ¼ skin unit are given at weekly intervals to each side of the face and, if there are numerous active lesions of the chin and fore-

head, an additional ¼ skin unit is given to the front of the face at bi weekly interval, the tip of the nose being used as a centering point. Usually sixteen exposures will be tolerated, and as a rule are sufficient to effect a cure. The first evidence of clinical improvement will not be noted until 1¼ to 1½ units have been given which will be in from five to six weeks. The skin must be watched carefully, and if there is marked dryness it is an indication for lessening the intensity of exposure, or discontinuing treatment for one or two weeks.

All cases should be carefully watched for the slightest evidence of erythema and at the first suspicion of its appearance treatment should be suspended for one or two weeks. This can be determined by contrast in observing the area about the eyes where the protected and unprotected skin merge. Also the skin should be watched for evidence of atrophy, which will first be noted on the chin and about the corners of the mouth. At the slightest evidence of this, treatment should immediately be discontinued.

During X ray treatment it is inadvisable to use any stimulating applications such as lotio alba, sulphur, etc, but an ointment of zinc oxid in unguentum aquæ rosæ may be applied to advantage. The affected part should be washed daily with soap and warm water. Careful regulation of the diet is important. Fried foods, pastry, candy, and all rich foods should be eliminated. The bowels should be regulated making sure of a movement each day. The diet should be maintained for at least six months after the last treatment.

If after five or six weeks satisfactory results are not obtained, or if the lesions are markedly indurated, it is well to use a filter of 1 millimeter of aluminum, administering ½ filtered unit (i.e. Filtered Kerr) each week for two or three weeks, then ½ filtered unit every two weeks for two treatments, and then ¼ skin unit unfiltered.

Cystic and Pustular Type.—The pustules should be evacuated and the routine treatment of ¼ skin unit given weekly. In this type of acne good results are obtained by the use of vaccines in connection with X ray treatments.

When the chest and back are affected the same procedure is advised, three areas being sufficient for the entire back. The anode is centered over the outer edge of each scapula for the upper back. For the lower back one exposure is used, the anode being centered over the spine at the level of the lower border of the ribs.

Recurrences do occur, but only in a small percentage of the cases. They are usually mild and respond readily to a second course of radiation, the time required and the amount of ray necessary being less. If a prompt response is not observed, it is unwise to persist.

Sycosis Vulgaris.—Probably no disease will tax the ingenuity and patience of the radiotherapeutist more than will sycosis, for the disease

will often prove most resistant, and it is frequently necessary to depilate in order to effect a cure

As it is sometimes not necessary to depilate, it is well to begin with fractional exposures of 1/4 skin unit once a week for five or six weeks. If, at the end of this time there is no improvement there remain two alternative methods. First, exposures of a filtered 1/2 skin unit at weekly intervals may effect a cure. Second depilation may be necessary. If the latter method is employed, extreme caution must be used in order to prevent a permanent alopecia. It is of equal importance that even a mild degree radiodermatitis should not result as this would be followed later by atrophy and telangiectasia. In order to produce a defluvium, 5/16 skin unit should be given once weekly for four exposures. From one week to ten days after the last treatment the hair will usually fall

Technic—When the disease is limited to the bearded region, exposures are given to five areas. The patient's position is the same as in acne

1 Center just below the zygoma on each side
2 Center just below the angle of the jaw on each side of the neck
3 Tilt the head backward and center just below the chin in the median line. Care must be used to prevent overlapping and it may be advantageous to cover with lead foil or lead rubber the parts not being treated. It is imperative that no irritating drugs be used for two weeks before during, or two weeks after the treatment

When depilation is complete, a mild ointment of ammoniated mercury (3 per cent) may be used

In the treatment of sycosis of other hairy regions, such as pubis, axillæ, eyebrows etc, the exposures are the same. If the eyebrows are affected it is advisable to cover the eyelids with lead foil

Hyperidrosis and Bromidrosis—Beneficial results can be obtained in this discomforting condition by X ray treatment. It must be borne in mind that it is only the sweat glands which must be affected and that under no condition must a *complete* atrophy of these glands be produced. Usually there is a decrease in the excessive secretion of the glands in a short time and it is at this period that caution must be exercised in order to avoid carrying the treatment beyond the point of safety

Technic—Either the fractional or suberythema method of treatment may be employed, at the discretion of the operator. If the fractional method is chosen, exposures of 1/4 skin unit are administered every week with a total of not over 1 skin unit in four weeks. If the suberythema exposure is employed, 1 skin unit repeated in four weeks is advised

If the hands are affected each hand should be irradiated separately the anode being centered at the highest point that is the thenar eminence

head, an additional 1/8 skin unit is given to the front of the face at bi weekly interval, the tip of the nose being used as a centering point Usually sixteen exposures will be tolerated, and as a rule are sufficient to effect a cure The first evidence of clinical improvement will not be noted until 1¼ to 1½ units have been given, which will be in from five to six weeks The skin must be watched carefully, and if there is marked dryness it is an indication for lessening the intensity of exposure, or discontinuing treatment for one or two weeks

All cases should be carefully watched for the slightest evidence of erythema, and at the first suspicion of its appearance treatment should be suspended for one or two weeks This can be determined by contrast in observing the area about the eyes where the protected and unprotected skin merge Also the skin should be watched for evidence of atrophy, which will first be noted on the chin and about the corners of the mouth At the slightest evidence of this, treatment should immediately be discontinued

During X ray treatment it is inadvisable to use any stimulating applications, such as lotia alba, sulphur, etc, but an ointment of zinc oxid in unguentum aquæ rosæ may be applied to advantage The affected part should be washed daily with soap and warm water Careful regulation of the diet is important Fried foods, pastry, candy, and all rich foods should be eliminated The bowels should be regulated, making sure of a movement each day The diet should be maintained for at least six months after the last treatment

If after five or six weeks satisfactory results are not obtained, or if the lesions are markedly indurated, it is well to use a filter of 1 millimeter of aluminum, administering ½ filtered unit (see Filtered Ray) each week for two or three weeks, then ½ filtered unit every two weeks for two treatments, and then ¼ skin unit unfiltered

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in which cases, to all clinical appearances parallel, show greater diversity of results when treated in the same manner

Whether this is because of the resistance of the patient the type of cancer, or the degree of malignancy of the growth is not clearly understood, but it is universally recognized Ewing recently gave the results of his experiments with X ray on the cancers of two rats As far as it was possible to determine by both macroscopic and microscopic examination, the growths were identical in both animals yet that of one was not destroyed by several times the amount of ray necessary to cause the death of all cells in the other This seems to indicate that some tumors are more resistant than others, and probably accounts for the widely dissimilar results in cases treated along parallel lines and leads one to question the statement so positively made by certain of the foreign investigators that the 'lethal dose for carcinoma is 110 per cent of an erythema dose

Many cases of carcinoma have been clinically cured by X ray (and after five or more years have shown no evidence of recurrence) One such case is still well although the last treatment was given ten years ago A better understanding of the methods of treatment and improved technic are giving a greater number of brilliant results, and warrant the hope that the problem may soon be solved At the present time results are not sufficiently uniform to justify the contention of the most enthusiastic advocates that X ray is the last word in the treatment of carcinoma, and that surgery should be discontinued in all cases In inoperable conditions the use of the ray offers positive relief of the symptoms, probable prolongation of life and perhaps regression and clinical cure

In operable cases probably the most efficient treatment and that offering the greatest possibility of a happy outcome consists in preoperative radiation to inhibit the tumor cells and to minimize the danger of dissemination by operative procedure radical surgical removal of the tumor within two to three weeks and postoperative radiation as soon after as possible in order to destroy any cells that may have escaped the surgeon's knife[3]

One of the greatest stumbling blocks in malignancy is the problem of metastasis Cases in which the most gratifying results in the local lesion are obtained within a few months after operation frequently show widespread metastasis especially to the bones Preoperative radiation has seemed to reduce the likelihood of such an unfortunate outcome, and as surgeons begin to realize its advantage and employ it more widely doubtless a decided advance will be made

In order to permit the use of the ray both before and after operation without loss of time picric acid preparation of the surgical field is advocated instead of the bichloride of mercury and iodin preparation usually employed (see Contraindicated Drugs)

on the flexor surface, and at the metacarpal phalangeal junction for the extensor surface

In irradiating the feet each foot should be exposed, the plantar surface being divided into two areas, and the unexposed area being covered with lead foil The dorsal surface is next exposed Centering just posterior to the metatarsophalangeal articulation, 1/4 skin unit is administered to each area

In hyperidrosis of the axillæ care must be taken to avoid too marked pigmentation, especially in the female, which may persist for several months and often cause much annoyance If the fractional method is chosen, 1/4 skin unit weekly may be administered but if the suberythema exposure is given, it is suggested that 3/4 skin unit be given and repeated in four weeks

Bromidrosis, which is usually associated with hyperidrosis, can be relieved and frequently cured by the use of X ray, the technic being the same as that outlined for hyperidrosis

Hypertrichosis —Without doubt there is no condition which the radiotherapeutist is more often called upon to treat than this While treatment has often been undertaken, and while at present new technics are being developed both in the United States and in Europe, until more perfect methods are developed, or the present experiments are more fully perfected, it should, in the author's opinion, neither be advised nor undertaken

In order to produce a permanent alopecia it is necessary to cause a complete atrophy of the hair follicle The sebaceous and sweat glands are less highly organized and more superficial Therefore in producing an atrophy of the hair follicle, it necessarily follows that there will be produced also an atrophy of these glands, with loss of elastic tissue, which is sure to be followed in from six months to a year by wrinkling and telangiectasia This unfortunate result, not being immediate, gives no warning From the medicolegal standpoint, neither a signed contract with the patient nor a warning of the untoward results which may follow *will protect the radiotherapeutist from legal complications*

When Filtered Radiation May Be Used

Carcinoma —Perhaps the greatest field for X ray therapy, and certainly the one that at present is holding the most widespread attention among physicians and laity alike, is that of carcinoma More experimental and research work is being done in the effort to find a dependable cure for this disease than for any other condition, and surely no other field holds so many brilliant promises, and at the same time imposes such discouraging and unforeseen obstacles There is no branch of pathology in which the individuality of each case is more clearly demonstrated, nor

contrast to the 110 per cent needed to destroy carcinoma Therefore it would seem that a cure of this condition by X radiation should be easy and certain, and that the most hopeful prognosis might safely be given Unfortunately, such is not always the case, and a guarded prognosis must be made because as in carcinoma, the degree of malignancy of the growth and its individual resistance to irradiation, cannot be accurately estimated In general, the round and spindle-celled types are more favorably influenced than are the osteosarcomata and chondrosarcomata a fact easily understood in view of the difference in the histological structure the latter being composed largely of connective tissue Sarcoma of the skin and lymphatic glands is usually amenable to irradiation That of the long bones even when recurrent after operation will frequently 'fade away' under this form of treatment

When the growth is in the mediastinum marked relief of the symptoms and a temporary arrest of the condition or even a regression in the size of the tumor, may often be obtained

As in carcinoma, it is advisable if possible to remove the growth surgically Postoperative irradiation should always be employed Preoperative use of the X ray is advocated and when such a procedure is followed if there is marked improvement in the clinical picture, and regression in the size of the tumor, it may be advisable to continue this form of treatment and postpone operative interference, the decision in this respect resting with the surgeon At all times the closest cooperation between the surgeon and the radiotherapeutist is essential to the welfare of the patient

Technic—This is practically the same as that employed in the treatment of the preceding condition

Uterine Fibroids—Excepting the pedunculated type and those in which the growth is at or above, the level of the umbilicus uterine fibroids can confidently be expected to disappear or markedly diminish in size under X ray treatment The reduction in the size of the tumor becomes noticeable after the second sometimes after the first treatment, and continues except for temporary enlargement during menstruation, until the mass can no longer be detected

The menorrhagia usually accompanying a fibroid is as a rule controlled after the first treatment, although in some cases the flow will show a temporary increase Premature menopause is caused which will be permanent if sufficient radiation has been administered but menstruation will be reestablished in from six months to two years if less than a sterilizing dose has been given With the resumption of the menstrual epoch the fibroid may again enlarge For this reason the patient should be kept under observation

Technic—Using a 9 inch gap 5 milliamperes at 10 inch distance and filtering through 3 millimeters of aluminum 7 to 8 minutes exposure

Technic.—The method of treatment will differ according to the type of radiation used, that is, whether the older 110,000 volt machine or the newer 200,000 volt type is employed.

Using the older method, the portals of entry for the ray are smaller in size, but more areas are irradiated. The section of the body in which the tumor is located is divided into small areas, 5 by 8 centimeters to 10 by 12 *centimeters (2 by 3 inches to 4 by 5 inches)*, a border of ½ to ¾ inch being left between the areas to prevent overlapping. These areas usually include the entire circumference of the body. Lead, or other suitable protective material, is so placed that the X-ray can reach only the area to be irradiated. These portals are then exposed in rotation to a maximum suberythema filtered exposure, the ray being directed through each portal toward the lesion, thus producing a cross-fire effect, which enables the maximum amount of ray to reach the tumor without causing *destruction of the superficial tissues. The operator must be warned* against too much cross-firing, as it is possible to produce a deep-seated necrosis without any apparent radiodermatitis.

The length of exposure of each area must vary with the factors used (spark gap, milliamperage, distance, filter), but not over 2 to 2¼ filtered units (four-fifths of an erythema exposure) should be given. Thus, using a 9 inch gap, 5 milliamperes, 25 centimeters' (10 inches) distance, 3 millimeters of aluminum (filter), 7½ to 10 minutes' treatment can be given to each area.

The number of areas irradiated at each session will vary with the total number of portals to be exposed, and with the condition of the patient. *Four to six areas are usually well borne, and sometimes more* may be tolerated. Wherever it is possible the total number of portals should receive treatment within a week's time, exposures being made on alternate days.

This procedure is repeated every four to five weeks for three series, and again eight weeks after the third course of treatment. If progress has been satisfactory, radiation is discontinued, but the patient is kept under observation for one or two years, and at the first unfavorable indication, treatments are resumed.

Too long-continued treatments will lead to atrophy of the subcutaneous tissues, telangiectasia, and even necrosis, so that, except in those cases where the gravity of the situation demands heroic measures, too many series should not be given.

In employing the 200,000 volt technic, a "depth dose" of 110 per cent *of an erythema exposure is administered to the growth*. The number and size of portals used, and the amount of exposure given to each, varies with the location of the tumor.

Sarcoma.—*The estimated "lethal dose" when the 200 000 volt technic* is used is 70 per cent to 80 per cent of the erythema exposure. this in

contrast to the 110 per cent needed to destroy carcinoma. Therefore it would seem that a cure of this condition by X radiation should be easy and certain and that the most hopeful prognosis might safely be given. Unfortunately, such is not always the case and a guarded prognosis must be made, because, as in carcinoma, the degree of malignancy of the growth and its individual resistance to irradiation cannot be accurately estimated. In general, the round and spindle-celled types are more favorably influenced than are the osteosarcomata and chondrosarcomata, a fact easily understood in view of the difference in the histological structure, the latter being composed largely of connective tissue. Sarcoma of the skin and lymphatic glands is usually amenable to irradiation. That of the long bones, even when recurrent after operation, will frequently 'fade away' under this form of treatment.

When the growth is in the mediastinum, marked relief of the symptoms and a temporary arrest of the condition, or even a regression in the size of the tumor, may often be obtained.

As in carcinoma, it is advisable, if possible, to remove the growth surgically. Postoperative irradiation should always be employed. Preoperative use of the X ray is advocated, and when such a procedure is followed, if there is marked improvement in the clinical picture, and regression in the size of the tumor, it may be advisable to continue this form of treatment and postpone operative interference, the decision in this respect resting with the surgeon. At all times the closest cooperation between the surgeon and the radiotherapeutist is essential to the welfare of the patient.

Technic.—This is practically the same as that employed in the treatment of the preceding condition.

Uterine Fibroids.—Excepting the pedunculated type, and those in which the growth is at or above the level of the umbilicus, uterine fibroids can confidently be expected to disappear or markedly diminish in size under X ray treatment. The reduction in the size of the tumor becomes noticeable after the second, sometimes after the first, treatment, and continues, except for temporary enlargement during menstruation, until the mass can no longer be detected.

The menorrhagia usually accompanying a fibroid is as a rule controlled after the first treatment, although in some cases the flow will show a temporary increase. Premature menopause is caused which will be permanent if sufficient radiation has been administered, but menstruation will be reëstablished in from six months to two years if less than a sterilizing dose has been given. With the resumption of the menstrual epoch the fibroid may again enlarge. For this reason the patient should be kept under observation.

Technic.—Using a 9 inch gap, 5 milliamperes at 10 inch distance and filtering through ° millimeters of aluminum, 7 to 8 minutes exposure

Technic—The method of treatment will differ according to the type of radiation used that is, whether the older 110,000 volt machine or the newer 200,000 volt type is employed

Using the older method, the portals of entry for the ray are smaller in size, but more areas are irradiated The section of the body in which the tumor is located is divided into small areas, 5 by 8 centimeters to 10 by 12 centimeters (2 by 3 inches to 4 by 5 inches), a border of 1/2 to 3/4 inch being left between the areas to prevent overlapping These areas usually include the entire circumference of the body Lead or other suitable protective material, is so placed that the X ray can reach only the area to be irradiated These portals are then exposed in rotation to a maximum suberythema filtered exposure the ray being directed through each portal toward the lesion, thus producing a cross fire effect, which *enables the maximum amount of ray to reach the tumor without causing* destruction of the superficial tissues The operator must be warned against too much cross firing, as it is possible to produce a deep-seated *necrosis without any apparent radiodermatitis*

The length of exposure of each area must vary with the factors used (spark gap, milliamperage, distance, filter), but not over 2 to 2¼ filtered units (four fifths of an erythema exposure) should be given Thus, using a 9 inch gap 5 milliamperes 25 centimeters' (10 inches) distance, 3 millimeters of aluminum (filter), 7½ to 10 minutes treatment can be given to each area

The number of areas irradiated at each session will vary with the total number of portals to be exposed and with the condition of the patient Four to six areas are usually well borne, and sometimes more may be tolerated Wherever it is possible the total number of portals should receive treatment within a week s time, exposures being made on alternate days

This procedure is repeated every four to five weeks for three series and again eight weeks after the third course of treatment. If progress has been satisfactory, radiation is discontinued, but the patient is kept under observation for one or two year, and at the first unfavorable indication, treatments are resumed

Too long-continued treatments will lead to atrophy of the subcutaneous tissues, telangiectasia, and even necrosis so that, except in those cases where the gravity of the situation demands heroic measures, too many series should not be given

In employing the 200 000 volt technic, a "depth dose" of 110 per cent of an erythema exposure is administered to the growth The number and size of portals used, and the amount of exposure given to each, varies with the location of the tumor

Sarcoma—The estimated lethal dose' when the 200 000 volt technic is used is 70 per cent to 80 per cent of the erythema exposure, this in

the ray, although some operators advocate their exposure, claiming that more immediate results are obtained Six to ten series are usually sufficient to overcome the condition

For expo ing the perineal area the knee-chest position is assumed Witherbee has constructed a special chair having the tube under the seat which greatly facilitates this treatment and is more comfortable for the patient. Py his technic only the perineal area is exposed treatments being given each week

Tonsils —Enlarged tonsils of the infected type are benefited by X ray treatment, their size being reduced to normal, the hypertrophied lymphoid tissue being destroyed, and the pus evacuated from all the crypts Cultures made from them after completion of the treatment are repeatedly sterile, and the systemic diseases produced by infection from the diseased tonsils are greatly improved, or cured

The effect of the ray is on the diseased lymphoid elements which are destroyed and replaced by connective tissue The contraction of the connective tissue fibers expresses the pus from the tonsil This being the case, no benefit results when radiation is applied to tonsils already fibrotic

Usually six to eight treatments are given at biweekly intervals The systemic condition as well as the recurrent sore-throats of which these patients usually complain, shows improvement after the second or third treatment the reduction in size of the tonsils becomes apparent after the fourth to sixth treatment The shrinking continues after treatment has been completed and it is not until after six months that they reach their ultimate size

Occasionally it happens toward the end of, or even after, the series that a white, glistening area will appear on the tonsil having the appearance of an absce s or patch This is due to the accumulation of pus in a buried crypt which the contracting conne tive tissue is unable to express through the covering membrane

If left alone such abscesses will eventually rupture but it seems advisable to incise them in order to rid the economy more quickly of the infected material

The objections to this form of treatment for tonsils, as advanced by the profession at large, are many and various, but are not substantiated by facts

Danger to Thyroid Submaxillary and Parotid Glands—Sometimes a treatment will be followed within twenty four hours by dryness of the throat and fauces which persists from a few hours to a day This condition is not permanent, and there has not been reported a single case properly treated that has suffered more than a very temporary diminution in the action of the glands

If the thyroid and parotid glands are of normal size, they will not

is given to each of four areas anterior, two over the uterus and one over each ovary, and on the second day following, to each of three corresponding areas posterior Treatment is repeated every four weeks

With the 200,000 volt machine, a 35 per cent to 50 per cent erythema dose is given Two portals, approximately 12 centimeters square (5 inches), are utilized, one on each side of the median line anterior

Menorrhagia—As in the above condition, the results of X ray treatment are uniformly satisfactory The same technic is employed, and, as a rule, three or four series are sufficient.

The age of the patient is a very important consideration If the time of the menopause is near, hastening it need cause no concern, but in younger women, particularly where there is a desire to bear children, it is advisable, if conditions permit to give only sufficient radiation to stop the excessive flow without causing a disappearance of the menstrual epoch

No definite or fixed rule can be advanced as a guide for the number of treatments necessary to accomplish this result Generally, however, after two successive menstruations have been missed, treatment may be discontinued, but the patient should be kept under observation for several months Treatments may be resumed if indications warrant

Chronic Mastitis and Fibromata of Breast—In chronic mastitis the pain and tenderness are quickly relieved, and the induration disappears Fibromata gradually diminish in size, and after two to four treatments can no longer be detected

The breast may be divided into from two to four small areas or the entire gland exposed through one portal, according to its size, and the extent of the involvement Using a 9 inch gap, 5 milliamperes, 10 inch distance, 2 to 3 millimeters of aluminum filter, two fifths to four fifths of an erythema exposure is administered to each area every four weeks

Prostatic Hypertrophy—The early relief from the frequency of urination afforded by the use of X ray, recommends its use, especially in those cases which are poor surgical risks The residual urine is quickly eliminated, and the patient is enabled to sleep through the night without discomfort. The general health, which in these cases is so undermined by the lowered function of the kidneys improves rapidly When the enlargement of the prostate is the result of calcareous or fibrotic changes, no benefit will result from radiation, but the adenomatous type will respond and uniformly good results will be obtained

Technic—Three areas are irradiated, two of which are situated anteriorly just above, and to either side of, the symphysis pubes the third includes the entire perineum Using a 9 inch spark gap, 5 milliamperes 10 inch distance, and a filter of 4 millimeters of aluminum, an exposure of four minutes is given every week as follows The two anterior areas are irradiated at the first treatment, one week later the perineal area is exposed It is advisable to protect the testes from the direct action of

Position of Tube.—The tube must be so placed that the central ray will strike the tonsil at right angles. This is most important.

Exposure.—Using a 7 inch gap, 5 milliamperes, 10 inch distance, 3 millimeters of aluminum, a three *and one-half* minute exposure is given to each tonsil every two weeks for six or eight treatments. In cases where adenoids are especially to be affected, a third area at the occiput is radiated every other treatment.

Cases are occasionally encountered in which irradiation every other week is impracticable. Under such circumstances the above method must be altered, and using an 8 inch gap, 5 milliamperes, 10-inch distance, and a filter of 3 millimeters of aluminum, an exposure of five minutes to each tonsil is made every five weeks for two or three treatments. This increased amount of exposure may be followed within twenty four hours by an edema of the pharynx, which will be alarming to the patient unless he has *previously been advised of the possibility of such a reaction*, and assured that it will be transitory and not serious.

Hyperthyroidism.—Toxic exophthalmic goiter is in most cases cured or markedly benefited by radiotherapy. The cystic and colloidal thyroid are not amenable to this form of therapy, since there is no glandular hypertrophy, and no toxicosis.

In conjunction with X-ray treatment, frequent tests of the patient's basal metabolism should be made, as it is the only absolute indication of the degree of toxicity, and consequently the only accurate guide for the frequency and number of treatments. When this test reaches + 10, or if the rate shows a rapid drop between tests, treatment should be discontinued, but the patient should be kept under observation for a year or two, and radiation resumed if toxic symptoms reappear or the rate of basal metabolism shows an increase.

The first improvement noted is a decrease in nervousness, reduction of pulse rate, and diminution of tremor. At about the same time the patient begins to sleep better, and there is less sweating. The basal metabolism usually shows a slight decrease, but occasionally it will remain at its high level for some time after the clinical picture indicates *improvement. A gain in weight is usually noted early.*

The goiter is usually, but not always, reduced in size, sometimes disappearing altogether. The exophthalmus is the last and least affected symptom. Frequently there is no change, but as nutrition improves and *emaciation* disappears, the prominence *of the eyeballs becomes less* noticeable.

If treatment is carried too far, myxedema will result, and it is in order to avoid this unfortunate sequel that it is advisable to have a metabolism test made before each treatment. Also by shielding the isthmus and thus protecting it from the effects of the ray, the danger of hypothyroidism is greatly lessened.

project into the field of exposure, provided the shielding is properly placed

Danger to Pituitary Gland.—This gland is protected from the direct action of the ray by lead shielding around the area radiated, and consequently cannot be injured

Danger to Skin and Hair.—With proper shielding and technic, insufficient radiation is applied to cause any damage to the integument or its appendages

Questionable Results.—It is true that some cases have not responded satisfactorily to irradiation, but such failures are due either to faulty technic or to improper selection of cases Nor are 100 per cent perfect result claimed by the advocates of this method, and there is no other form of tonsil therapy, not excepting surgery, where 100 per cent cures are obtained.

Length of Time.—This is a valid objection to this form of treatment, and, in cases where immediate elimination of the affected focus is essential, other measures should be employed

On the other hand, the benefit from the treatment is seen relatively early, and in most cases the actual time lost is small The advantages of this form of treatment may be briefly summed up as follows

1 Elimination of danger of death from anesthesia and postoperative hemorrhage

2 Avoidance of the possibility of lung abscess following tonsillectomy

3 In cases where surgery is contraindicated as in diabetic, hemophilic, and cardiac conditions this method offers a safe and almost certain means of eliminating tonsillar focal infection

4 By this method of treatment not only the tonsils but the peritonsillar tissue and pharyngeal adenoids are benefited

Technic—Position.—The patient assumes the prone position, head turned to the side, resting on the ear, and slightly lowered to increase the distance of the angle of the jaw from the neck The chin is tilted upward further to increase this distance Thus we have a site bounded by the ramus of the jaw anteriorly, the anterior border of the sternocleidomastoid muscle posteriorly and the level of the tip of the mastoid process superiorly, through which the ray will pass, not only to the tonsil, but to the peritonsillar tissue and the pharyngeal vault

Shielding.—An opening 2¼ by 3½ inches is made in a sheet of lead foil at least 3/16 inch thick This is so placed that the tip of the mastoid process projects slightly into the opening at the center of the upper margin The anterior border is slightly anterior to the posterior border of the ramus of the jaw The head, face, and shoulders are covered with lead protective

of reasonably good health It has been observed by some authors that the cases responding most rapidly to X ray therapy are more prone to early recurrence, and in these the prognosis is least favorable

The first evidence of improvement is a diminution in the size of the glands This frequently occurs very soon after the first treatment has been administered Cough, dyspnea and other indications of mediastinal pressure if present are the next to be relieved The discoloration of the skin is usually the last symptom to show improvement

Technic—Some operators prefer to expose only the areas in which there is glandular enlargement giving two fifths to three-fifths of a filtered erythema exposure every four weeks There are certain advantages in this method particularly where it is necessary for patients to travel a considerable distance for treatment and the fatigue of travel makes frequent trips inadvisable The best result have been obtained by dividing the trunk into twelve areas three areas on each side of the chest and abdomen and three on each side of the back and exposing three areas every third or fourth day to one-fifth of an erythema exposure By this method the anterior areas are exposed one week and the posterior areas the next In this way each area is exposed once every two weeks It has not been found necessary to direct the ray toward the enlarged glands themselves and it has been noted that those lying outside the areas radiated show the same diminution in size as do those within

Using a 9 inch gap 5 milliamperes 10 inch distance with filter of 3 millimeters of aluminum two and one half minutes exposure is given to each area

Treatment must be administered regularly and continued except for an occasional rest until the clinical picture is normal Subsequently the patient must be kept under observation, and treatment resumed at the first evidence of recurrence of symptoms With each recurrence the difficulty of controlling the disease may be increased, and the length of time between recurrences gradually diminishes until the patient finally succumbs

Leukemia — As in the preceding condition the leukemias are chronic, recurrent diseases whose termination is always fatal but the progress of the disease may be temporarily arrested, and from a few months to two years of comfort and activity added to the life of the patient by radio therapy One case has been reported in which the patient lived seven years

The white cell count is the guide for the amount of radiation and number of treatments no radiation being given after the count reaches 15 000

Technic—The treatment is usually directed to the spleen and long bones, one-twelfth to one-eighth of an erythema exposure being given to each area every two weeks The spleen is divided into twelve areas four

The thymus is very frequently involved in hyperthyroidism Consequently it is customary with most operators to expose it at each treatment In many cases, instead of exposing the thymus, an area on the back of the neck, extending from about the fourth cervical to the second dorsal vertebra may be irradiated Results from this method have been equally satisfactory, the effect probably being due to the action of the ray on the sympathetic nervous system Before X ray treatment is instituted, it is advisable that a careful examination of the patient be made to eliminate the possibility of a focal infection or other underlying condition which may be the causative factor, for no benefit will result from irradiation until such source of infection has been removed

It is a common belief that following X ray treatment of the thyroid there occurs extensive formation of connective tissue around the gland, which increases to a marked degree the difficulty of subsequent operation, if such procedure is necessary This contention is without substantiation, by both experimental findings and the experience of the majority of operators

In case of hyperthyroidism associated with menstrual disorders, no benefit may be obtained from irradiation of the gland With such patients, radiation applied to the ovaries will frequently correct both the menstrual and thyroid trouble

Technic —Using an 8 inch gap, 5 milliamperes, 10 inch distance, and filtering through 3 millimeters of aluminum, 3 to 5 minutes' exposure is given to each lobe of the thyroid and to one area over the thymus (or back of neck) every two or three weeks for three or four treatments If after the fourth treatment, there is no improvement, the case is regarded as unsuitable for this form of therapy, but if the clinical picture shows satisfactory progress, treatments are again resumed after two months, and a second series of three or four treatments is given It has sometimes been found necessary to repeat these series several times, some cases having required as long as two and one-half years to cure, but usually a year or less is sufficient

When irradiating the ovaries, one-fifth of an erythema exposure should be administered to each ovary

In patients whose toxicosis is extreme where collapse is imminent, X ray is contra indicated its administration being sometimes followed by death Such cases should be treated by other measures in an effort to improve the patient's condition sufficiently to permit radiation

Hodgkin's Disease —Although X ray therapy will not permanently cure Hodgkin's disease it will so ameliorate the symptoms reduce the size of the glands, and improve the general condition, that months, or even years of comfortable and active life may be afforded the patient In cases with the most unfavorable prognosis, patients have, as a result of treatment, been able to return to their usual occupations and the enjoyment

picric acid or simple alcohol preparation, the aspiration of these glands may be accomplished without interference with X ray therapy. The incision usually heals rapidly but if difficulty of closure is experienced, a single exposure of the area to unfiltered radiation will in most cases hasten recovery.

Improvement is first noted in the lessening of the pain in the glands, later in a reduction in their size. They become firmer, and eventually entirely disappear, or, when calcification takes place, only a small stone-like nodule remains.

Technic.—Various operators use different thicknesses of filter from 1 to 5 millimeters of aluminum being advocated. No material advantage has been observed in any definite thickness of filter but it has been the author's custom to use 1 or 3 millimeters of aluminum and with an 8 inch gap, 5 milliamperes at 10 inch distance to give an exposure of from two to four minutes every three weeks. Better results have been obtained by dividing the neck into small areas and exposing each area to this amount of radiation than by exposing a single area including the one entire side of the neck. Exposing the opposite side of the neck for the benefit of cross fire is advantageous.

Using the 200,000 volt technic, a one-third erythema dose is administered once every three weeks.

Tuberculous Peritonitis.—The benefit obtained from X ray therapy is remarkable in this condition, improvement being noted almost immediately after treatment is begun. The abdomen is divided into four areas, corresponding to the quadrants and each week one-fifth of a filtered erythema exposure is administered to each of two areas.

Tuberculous Osteomyelitis.—X ray treatment of this condition frequently proves beneficial. One fifth of an erythema exposure every two or three weeks usually produces more satisfactory results than more intensive radiation less frequently administered. The discharging sinuses soon heal and the progress of the disease is arrested, but regeneration of the bone is not to be expected.

Pulmonary Tuberculosis.—Although a great deal of investigative work with X ray has been conducted in an effort to combat this disease the results have not been uniform or, in many cases even satisfactory. Some patients have benefited greatly by this form of therapy which has many strong advocates. The consensus of opinion is that fractional exposures are superior to massive, two areas anterior and two areas posterior being exposed to one tenth to one-fifth of a filtered erythema dose every other week.

Sinusitis and Mastoiditis.—The use of X ray in the treatment of acute and subacute sinusitis and mastoiditis is coming into greater prominence as the benefits derived from its administration are more widely appreciated. Cases characterized by pain over the affected cells and a constant

anterior, four lateral, and four posterior, four of which are exposed every other day during one week. The following week the extremities are exposed, as follows: On the first day one area on the anterior and one on the posterior surface of each arm, and of each forearm is exposed. On the third day three areas on the anterior surface of each leg and thigh, and on the fifth day corresponding areas on the posterior surface are irradiated.

It has been observed that a continuance of treatment for a prolonged period *sometimes results in the establishment of an apparent immunity* of the patient to X ray. In such cases, it has been noted that a complete change in the method of administration was immediately followed by improvement. One case of this kind was treated according to the above method for several months. The white blood count, originally 236 000, was reduced to 40,000, but could not be further lowered. By changing the technic and using that outlined for Hodgkin's disease, excepting that smaller amounts of radiation were administered, the count was quickly lowered to 10 000.

Using 8 inch gap, 5 milliamperes, 10 inch distance, and 3 millimeters aluminum filter, from one to two minutes exposure is given to each area.

Banti's Disease.—In the limited number of cases of Banti's disease which have been subjected to X ray therapy, the reports indicate favorable results, with reduction in the size of the spleen and improvement in the general condition of the patient. The spleen is never reduced to normal size, which is easily understood in view of the pathological changes in this condition, as the organ is already undergoing fibrous degeneration. The greatest reduction in size reported is about 50 per cent. This relief, of course, is only temporary, and cure cannot be expected.

Technic.—*Radiation is directed to the spleen*, which is divided into small areas, so exposed that each will receive one-tenth of a filtered erythema exposure every week.

Tuberculous Adenitis.—Disappearance, or marked diminution in size, *and subsequent calcification of the glands, can confidently be expected* in tubercular adenitis. However, treatments must be continued at regular intervals and for a sufficient length of time. Indeed, the only difficulty in the conduct of this condition is the length of time involved, which is discouraging to the patient and causes *him to seek other measures of treatment* producing more immediate results.

The more recent the condition, the more rapid the response. The firmer the glands, the more readily they are influenced by the ray. Some cases require only four to five treatments, *while others will require a* year or more before all glands disappear or calcify. Glands which have broken down, or in which fluctuation is noted, should be incised and free drainage established before irradiation, otherwise the pus will eventually break through the skin, and more extensive *scarring result*. By using

CHAPTER XV

ORGANOTHERAPEUTICS

A. J. Carlson

INTRODUCTION

Definition.—The term "organotherapy" may be defined as *the successful control of the disease syndrome due to the hypofunction of an organ by administration of the organ itself or of substances prepared from this organ.* Other terms, sometimes employed synonymously with organotherapy, are opotherapy, zootherapy, histotherapy, sequardotherapy, hormone therapy, etc.

The above definition strictly excludes *organ transplantation* as a part of organotherapy. It also excludes the principles and methods of using substances derived from animal organs for specific actions not primarily related to the function of that organ in life; for example, the use of pituitrin or extracts of the posterior lobe of the hypophysis to control the uterine contractions in labor, the use of thyroid substance to control obesity, the use of adrenalin to control local hemorrhage or retard local absorption.

Organ Transplantation.—There is a much wider range of possibilities in organ transplantation than in organotherapy. When physiology and surgery shall have advanced to a point where an organ like the kidney can be transplanted as a permanent substitute for a diseased kidney, no one doubts that the symptoms of nephritis due to the diseased kidney will be permanently controlled. But no amount of advance of chemistry and biology will ever enable us to cure uremia due to kidney disease by the administration of kidney extracts.

It is, or ought to be, evident that organs like the liver, the lungs and the kidney, which through the action of their living cells remove toxic substances from the blood, control the chemical equilibrium and the metabolism of the body not through substances stored up in the cells and given off to the body fluids, but through processes dependent upon their living structure. The control of deficiency of this type of organs by administration of organ debris or organ products is as futile as the attempt to re-

out, radiotherapy, from the *standpoint of technic divides itself into two* branches, that is, superficial or unfiltered treatment, indicated in the majority of dermatological conditions, and deep or filtered therapy, indicated in conditions involving the deeper tissues As stated, only the more important diseases have been discussed There are many other conditions which respond favorably to the ray, such as verruca, callosity, syringoma, scrofuloderma, erythema induratum, furunculosis, etc For a detailed study of the X ray in connection with skin diseases, the author recommends the book entitled *X ray and Radium Treatment of the Skin* by Dr George M MacKee, which is doubtless the leading work on that subject

X ray must not be regarded in the light of a panacea or cure-all In many cases it does not cure at all, but merely inhibits the pathological cells, allowing the normal body forces to perform their normal functions, and sometimes merely affording relief In some conditions X ray alone will effect a cure In others it is only a valuable adjunct to other forms of treatment In many cases X ray is tried as a last resort, when other measures have failed Too quick and too brilliant results must therefore not be expected, but time must be allowed, and this form of treatment *regarded with the same tolerance as other forms of therapy* It must also be remembered that in certain diseases no hard and fast rules for treatment can be laid down, but each case must be treated as an individual one In such instances it is impossible to give a satisfactory prognosis

Generally speaking, the X ray *has an unlimited field of usefulness* in medicine and is one of the most valuable therapeutic agents which modern science has to offer Its success, however, depends upon careful diagnosis, the proper selection of cases, a thorough and well mastered technic, and a close cooperation between the physician or surgeon and the radio therapeutist Finally, while at the present time X ray therapy has its limitations and must not be regarded as a panacea yet its scope of usefulness is constantly increasing, and, with a better understanding of its value and a closer professional cooperation, it presents unlimited possibilities for the future

The use of animal extracts in medicine is referred to in the *Papyrus Ebers* one of the oldest manuscripts in the history of medicine Organs or organ extract of animals had a place in the medical superstitions of the ancient Hindus and in the therapy of Hippocrates Dioscorides and Galen The naive empiricism of the organotherapy of the early Greek physicians was not improved upon by the physicians of the Middle Ages We find that the liver of the pigeon and the wolf was recommended for hepatic disorders powdered human heart and the brain of the rabbit for epilepsy, extract of human brain for debility the lung of the fox for dyspnea rennet for gastric disorders the testicles of the donkey and the stag for depressed sex functions, etc

It would seem that the use of extracts of lung liver kidney, etc, to cure hypofunctioning of these organs presupposes complete ignorance of the physiology of these organs How much urine will be excreted by a dried and powdered kidney or how is it possible for a lung extract to send oxygen into and to take carbon dioxid out of the blood? But liver, kidney brain etc, in powder form tablets, or solution are on the market to-day as therapeutic remedies Studying the lists of organotherapeutic preparations on the market to-day all claiming support from clinical results one gains the impression that some of our drug manufacturers are guided by the medical superstitions of the Orient, and by medieval medical lore rather than by the modern sciences of physiology pharmacology and pathology

The hundreds of glandular products listed in trade journals include brain spinal cord, liver, lung bronchial gland lymph glands spleen carotid gland muscle leukocytes, blood bone marrow etc They do not differ greatly from the lists of a century or two ago the chief difference is that the 'indications are expressed in more modern but none the less obscure phraseology The therapeutic use of many of the organ preparations by the physicians of to-day is a discouraging instance of *therapeutic atavism*

The older organotherapy was based on the belief that it was possible to influence a diseased organ by the administration of the same but healthy organ from animals modern organotherapeutics is concerned primarily not with the condition of the organ diseased but with the activities of other organs which are impaired by the absence or diminution of an internal secretion of the diseased organ Thus thyroid is not given primarily for its effect upon the thyroid gland but for its effect upon various other organs whose activities are in part dependent upon the internal secretion of the thyroid

Recent experimental and clinical work in this field has accordingly been directed to two chief aims (1) the demonstration that various organs produce internal secretions and (2) attempts to determine the conditions under which these may be utilized for therapeutic purposes

pair the effects of a broken wheel in the machinery of a watch by pouring into the watch case a powdered watch wheel A whole wheel and nothing else will start the watch machinery going But in actual practice, at present, there is not a sharp distinction between organotherapy and organ transplantation, at least as regards some of the endocrine glands It is a fact that transplantation of a thyroid or an ovary from one person to another has so far been only a temporary success The *transplanted organ undergoes atrophy or lysis and absorption*, sooner or later, that is, heterotransplantation of any of the glands of internal secretion amounts to little more than the subcutaneous or intramuscular administration of the extracts of these organs The surgery of heterotransplantation of an endocrine gland is simple, the reasons for only a limited life of the graft are partly known but there is little hope that the modification of individuality within the species necessary to render the transplant permanent will be an accomplishment of to-morrow

The continued study of the chemistry and biological reactions of extracts of animal organs will gradually reveal substances having specific and useful drug actions not related to the living role of the organ in the intact animal At present we have two such substances in epinephrin and pituitrin When epinephrin is used in medicine as a local styptic or in bronchial asthma and pituitrin to induce uterine contractions, these are as distinctly drug actions as the use of digitalis to stimulate the heart or atropin to dry up the secretions No one supposes that the physiological actions of the latter alkaloids in the animal body bear any relation to the role of these alkaloids in the plants which produce them The hypophysis antedates the uterus in animal evolution by myriads of ages, and, so far as we know, the mammalian male has the same kind of hypophysis as the female If the term organotherapy is to include these distinctly drug actions and uses of animal substances, it seems we ought to speak of the useful actions of vegetable alkaloids as *plant organotherapy*

On the other hand it is being recognized that some of the effects of well known drugs may be due to specific actions upon organs of internal secretion Some of the effects of iodin for example, may be due to the fact that it increases the amount or potency of the internal secretion of the thyroid There is evidence that certain foods also increase the activity of some organs of internal secretion

The definition includes the successful use of digestive enzymes in the control of the disorders of digestion following hypofunction of the digestive glands But as commonly understood, *organotherapy is limited to the use of specific substances or hormones from the organs of internal secretion*

History—Empirical organotherapy or the attempt to control symptoms of organ disease by feeding the patient the healthy organs of animals, is one of the oldest forms of therapeutics

but other important liver function, such as glycogen storage protein deamidization, synthesis of urea from ammonia desaturation of fats bile formation, etc, cannot be carried out by liver extracts The futility of brain extract therapy in the case of defects or destructive lesions of *the nervous tissue equally apparent*

The only possibility for organotherapy in the case of the tissues just referred to is the chance or evidence that these tissues contain substances capable of stimulating the impaired organ or organs to increased activity For example, the kidney may contain a substance that stimulates the living kidney cells to increased secretory activity although the substance itself cannot secrete urine It is supposed for example that the mammary glands contain galactagogue substances Substances may be prepared from the gastric mucosa that induce secretion of gastric juice when injected into the blood The liver contains a cholagogue in so far as it contains bile elements Nervous tissue is rich in lecithin and some have held that administration of lecithin is favorable for the growth and metabolism of nervous tissue, etc

The existence of such *specific organotropic substances* in these various organs must first be demonstrated by accurate laboratory experiments before one is justified in using such organ extracts on patients where even under the best of conditions all the factors cannot be controlled The indiscriminate use of tissue extracts in maladies of unknown or complex origin leads to confusion At least one can place little credence on the results of such clinical use of organ extracts until supported by laboratory experiments on animals This principle must be insisted on all the more since many of the clinical lesions of the kidneys lungs liver and brain *can be reproduced experimentally in animals*

A typical case in point is the testicular ' permin ' of Poehl, which was proclaimed as a general metabolic stimulant, and for a time used as a cure-all by a few uncritical enthusiasts

Primary Hyperfunction Not Altered by Organotherapy—There is little or no hope for successful organotherapy in diseases due or supposed to be due to a primary hyperfunction of organs Where a malady is definitely traced to primary hyperfunction of an organ the remedy is surgical (direct or indirect), not medical But the question of an out and out organ hyperfunction including serious clinical disorders is at present a complex and uncertain chapter in medicine Gastric hypersecretion or hyperacidity is supposed to cause certain symptoms in gastric and duodenal ulcers, and in so called vagotonia The syndromes of toxic goiter, acromegaly hemolytic jaundice, and certain types of anemia hypergenitalism and osteomalacia are held by many scientists and clinicians to be caused by hyperactivity of the thyroid, hypophysis spleen pineal body adrenal cortex, and gonad respectively If it shall be clearly established that sufficient hyperactivity of these and other glands of internal

Great progress has been made in the former attempt, it has been shown that many organs produce internal secretions essential to life, or essential to normal life Much less progress has been made in the successful utilization of these internal secretions in disease, and we are only beginning to be able to explain the cause of some of the failures

The first step in rational organotherapy was taken by Brown Sequard in 1889, in his work on the physiological effects of extracts of the testicles The work of this French physiologist was not well controlled, and his claims greatly exaggerated Nevertheless, his theory that "all glands, whether they have excretory ducts or not, secrete useful principles the absence of which is felt when these glands are extirpated, or destroyed by disease," foreshadowed the modern "hormone' physiology Rational organotherapy was finally established in the early nineties by the successful control of the symptoms of thyroid hypofunctioning by the use of thyroid extract through the work of Schiff, Reverdin, Kocher, Fox, Mackenzie, Murray, and others This brilliant achievement has had two effects on subsequent biological investigation and clinical practice (1) it has been a potent stimulus in establishing similar types of function and methods of practical control for other organs of the body, (2) it has stimulated the clinical use of other organ preparations without definite physiological indications of their value and without experimental control

GENERAL PRINCIPLES OF ORGANOTHERAPY

Hormone Substance Essential —Successful treatment of the symptoms of hypofunction of an organ by extracts of said organ requires that the essential function of the organ consists in producing a substance or substances in the nature of hormones

It follows as a necessary corollary to this principle that organotherapy is out of the question in the case of tissues in which the production and storage of such substances are either absent or of no fundamental importance in the function of the organ The lung tissue permits or produces the exchange of oxygen and carbon dioxid between the blood and the air So far as we know the lung tissue does not store any substance that can in any way facilitate lung function or act as a substitute for the living lung Hence, the certain futility of lung extract therapy of pneumonia or pulmonary tuberculosis

The same general situation exists in regard to the kidneys the liver, the nervous tissue, the heart and muscular tissue in general, and possibly other organs No amount of flooding of the body fluid with kidney extracts can separate the urinary constituents from the blood in the absence of living kidney cells The liver plays a complex part in the body, and part of its function may be the production of important hormones,

but other important liver functions, such as glycogen storage protein deamidization synthesis of urea from ammonia desaturation of fats, bile formation, etc cannot be carried out by liver extracts The futility of brain extract therapy in the case of defects or destructive lesions of the nervous tissue equally apparent

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of these substances are produced by the gland cells and are of equal importance in gastric function The reason is evident Pepsin is stored up as pepsinogen in the resting cells while the hydrochloric acid is not stored up but discharged from the cell as soon as formed Hence a gastric mucosa extract contains the former but not the latter and in organotherapy of the gastric mucosa hydrochloric acid must be added from some other source Analogous conditions may obtain in some of the endocrine glands It is, therefore, important in determining to what extent the internal secretions are stored in the organs producing them and how much of them is necessary to maintain health This is possible in a general way in the case of a few organs Thus, from studies on the amount of thyroid which it is necessary to administer to maintain health in animals or man suffering from removal or disease of the thyroid it is possible to form an approximate estimate of how much thyroid secretion is necessary and from the weight of the gland how much material is stored in it. Such calculations show that the normal thyroid contains sufficient secretion to meet the demands of the body for several weeks

From a determination of the amount of epinephrin contained in the blood of the suprarenal vein and from the rate of blood flow through the suprarenal glands it is possible to make a rough estimate of the amount of epinephrin produced daily When the amount is compared with that actually found on chemical analysis in the suprarenal glands, it is found that the latter is equal to the epinephrin output for only a few hours Since some of the internal secretion is almost invariably lost or destroyed in the manipulations necessary to prepare the gland for administration, it is evident that the conditions in the case of the thyroid are far more favorable for success than in the case of the suprarenals and the pancreas

In addition to knowing how much of the secretion is stored in the gland, it is important to know how urgent is the body's need for the secretion and how long the latter remains in the body Light on these questions has been obtained by determining how soon symptoms appear after removal of the glands Taking two extremes it has been found that symptoms may not appear for weeks or months after removal of the thyroid whereas they appear within four to eight hours after removal of the pancreas and they may appear within a few hours after removal of the parathyroids or the adrenal cortex. It is evident that the chances for successful organotherapy are much more favorable in the case of the thyroid gland

Stability of Hormone —The physiologically important hormone stored in the gland must be sufficiently stable to resist the necessary chemical processes of making the gland extract, and for practical organotherapy the hormone must resist the action of the digestive enzymes and must be absorbed into the blood in active form.

This is probably the most serious limitation of organotherapy All

secretion cause disease, the only type of organotherapy that may be of value is the administration of organ extracts that depress the hyperactive gland—if there are such extracts For example, it has been reported that administration of ovarian extract to young male animals retards the development of the testes, and the observations of Lillie on the Freemartin seem to show that the testicular and ovarian secretions have some mutual inhibitory action on the development of the respective sex characters, at least in early embryonic life This type of organotherapy is at present purely empirical, and should be well grounded by animal experiments before it is applied to patients If the hyperactivity of a gland is a compensatory one, administration of extract of that gland may arrest the gland growth but will not control any other symptoms The 'hyperplasia' that may be induced in some endocrine glands by extirpation of other endocrine glands is no evidence that the extirpated glands secrete hormones holding the other glands in check Hence, there is at present no experimental basis for a pituitary organotherapy of toxic goiter If the glandular hyperplasia and hyperactivity is primary, such organotherapy is clearly contra indicated

Dystrophy and Perverted Secretion—There are at present no definite indications for organotherapy in disease due or rather supposed to be due to organ dystrophy, that is, a perverted or pathogenic secretion

The theory of a perverted or pathogenic secretion as the cause of disease has been advanced for some of the maladies related to the glands of internal secretion, notably the thyroid and hypophysis The theory has little or no basis in established fact But assuming it is true, the following possibilities must be considered (1) The gland may yield both the normal and the pathogenic secretion In that case the patient will show no symptoms of glandular hypo activity, the symptoms of the disease being solely due to the perverted secretion In such a case specific organotherapy will in all probability prove useless, as there is no reason for believing that the normal secretion of the gland will control the pathological secretion (2) In yielding the pathological secretion the gland may be so altered that the normal secretion is diminished or absent This is the most likely condition In such a case the syndrome will be a complex of glandular hypo activity and pathogenic secretion, and it is obvious that organotherapy may have a favorable effect on the hypoglandular symptoms but leave the pathogenic secretion symptoms unaffected

Accumulation of Hormones—The hormone or hormones must be stored up in active form, and in some quantity in the organ producing them, for successful organotherapy of this organ

It is obvious that unless the specific hormone in question is stored in the gland to some extent, administration of the gland extract in hypofunction of the gland will be useless For example, a glycerin extract of gastric mucosa contains pepsin, but no hydrochloric acid, although both

Hedon claims that when the blood from the pancreatic vein is introduced into the portal circulation of a diabetic animal there is a diminution of the glycosuria while it has no effect when introduced into the general circulation Thus he concludes that it is necessary for the internal secretion of the pancreas to reach the liver in order that it may be active But Hedon's results are disputed by Carlson In any event, it is a fact that the establishment of an Eck fistula in animals does not induce hyperglycemia and glycosuria on ordinary carbohydrate rations despite the fact that by this operation all the portal blood including that from the pancreas is sent into the general circulation before a small fraction of it reaches the liver by way of the hepatic artery Hedon's theory is untenable in view of this fact But we have a classical example of such distant activation in trypsinogen and enterokinase, and the possibility of analogous conditions in the gland of internal secretion where all attempts to isolate or demonstrate active hormones have so far been failures must always be kept in mind and tested

Standardization of Products—The hormones must be relatively stable in the form in which the gland or gland extract is put on the market for therapeutic or research purposes and the organ preparations must, so far as possible be chemically and physiologically standardized

No argument is needed in defense of this principle, although it is not always complied with Stability of the hormones may not be attainable, in which case we must have recourse to fresh glands or fresh extracts The only criticism that may be legitimately directed against manufacturing concerns in such cases is for failure to indicate the date of preparation of and the rate of deterioration of the extract While pancreatic secretin has so far proved to be of no therapeutic value it can be prepared in active form but not kept from rapid deterioration, so that the preparations on the market become inert in a few weeks This would be serious in case the active secretin was of any value in curing or controlling disease

The chemical and physiological standardization of such substances as thyroid pituitary and adrenal extracts or "insulin" is just as important as the standardization of diphtheria antitoxin It should be insisted on by the profession and required by law, in view of the fact that the preparations on the market may show great variations in physiological activity This is obviously a great drawback to the successful use of these substances in disease The standardization of insulin is imperative in view of the serious consequences of an overdose of this substance

The importance of chemical and physiological standardization of preparations of the parathyroid and the corpus luteum is equally obvious The parathyroids are very small organs distributed on and in the thyroids and in some cases in the thymus It takes a good deal of training and care to avoid the inclusion of small accessory thyroids or nodules of thymus in gathering fresh parathyroid material There is some evidence

hormones are probably (in fact, *must* be) soluble in serum or Ringer's solution But, because of the necessity of continuous or daily administration, intravenous or hypodermic injections of extracts of the entire glands produce toxic effects, in some cases more serious than the symptoms treated, owing to the presence of injurious tissue split products The chemical manipulation necessary to remove these toxic by products introduces greater chances for destruction or loss of the hormones themselves Moreover, intravenous or hypodermic injections must as a rule be done by a physician or a nurse, and even when this is done there are chances for local and general infections when employed daily or several times a day for months and years This is one of the difficulties of the insulin therapy of diabetes *Practical organotherapy thus limits itself in most cases to administration of the gland or the gland extract by mouth* That is, the hormone must run the gamut of enzyme action both in the lumen of the alimentary tract and in the wall of the absorbing intestine In view of this fact, the failures of organotherapy are less surprising to biologists than the striking success in the case of the thyroid If the founders of thyroid organotherapy had known of the general completeness of the protein and fat hydrolysis in the digestive tract, we believe they would scarcely have had courage to try the feeding of thyroid in myxedema and cretinism

Classical examples of destructive action of the digestive enzymes on hormones and alleged hormones, or failure of these hormones to reach the blood in active form when administered by mouth, are *epinephrin pituitrin insulin* and the *pancreatic* and *gastric secretins*

Activity of Hormone —The hormone must be present in the gland in active form, be activated by the chemical processes of preparing the extract, or the normal activator added to the gland or the extract

The thyroid hormone, as well as epinephrin pituitrin, "insulin," are present in the glands in active forms or activated by the processes of extraction Whether any of the other internal secretions are stored as pro hormones and must be activated in or by the products of other organs has not yet been determined Munser assumes that all the endocrine glands work in pairs one activating or inhibiting the other He therefore concludes that before an organ is used in organotherapy it must be "activated" by previously removing the inhibiting gland from the animal For example, before using the pancreas of an animal to control pancreatic diabetes in a patient, the animal must have had the anterior lobe of the hypophysis extirpated some time before the pancreas is excised in order to yield an "activated" pancreas This fanciful theory is not borne out by the well established facts of thyroid organotherapy, and we shall point out later that extirpation of some of the alleged inhibitors of the adrenals do not influence the epinephrin content of the gland

telligent cooperation of the clinic and the laboratory will assure a quicker arrival at the truth

The Dangers in Organotherapy—When as in the case of the thyroid oral administration is effective, this method should be used exclusively as a routine procedure There is danger in overdosing with thyroid extract even when given by mouth but all of the other endocrine preparations can be administered *per os* in large doses and for long periods with little or no deleterious effects There may also be no evidence of beneficial effects, but that is another story We are now concerned with the *dangers* of organotherapy

Intravenous organotherapy is the most dangerous hypodermic and intramuscular administration is less dangerous than the intravenous route, but hypodermic injections of crude organ extracts are capable of seriously injuring the patients through (1) anaphylaxis (2) toxic protein derivatives (histamin, peptones, etc), (3) toxic lipoids (cholin neurin etc) (4) local damage of tissues at the site of injection Hence is a general principle, *organ extracts of unknown composition (and this includes all of them except thyroxin adrenalin and with some reservations pituitrin and insulin) must not be given intravenously or hypodermically especially when repeated administrations are called for* Crude endocrine products parenterally administered introduce the additional danger of non specific protein therapy We must clearly recognize that intravenous or hypodermic therapy is always unphysiological and should be used only with pure products, and when the oral route yields no results, or too slow effects

The principle laid down in this paragraph puts a serious task before the manufacturer of organotherapeutic products a task demanding the highest grade of scientific ability and complete integrity in fact a higher type of accuracy and integrity than that required in ordinary honest business

Early *versus* Late Therapy in Endocrine Hypofunctions—The importance of early diagnosis and therapy of hypofunctions of the gland of internal secretion is obvious since the early therapy may check further deterioration in the gland system primarily involved and prevent the development of non reversible atrophies or abnormalities in other organs Early therapy may thus be effective while late treatment is less or even non effective But sex aplasia and absence of adolescence due to hypothyroidism may, in some cases at least be corrected by thyroid organo therapy begun as late as the thirtieth or fortieth year

While we all subscribe to this principle the great difficulty comes in the application from the fact that *none of the incipient symptoms of hypo function of any endocrine system are specific* For example the primary etiology of slight nervous disturbances slight adiposity slight disturbance in growth slight disturbances in sex functions, slight disturbances

of variation in function of corpus luteum with the age of this temporary organ, and with the incidence of pregnancy Even the most careful manufacturer, therefore, is facing great difficulties, since his only sources of material are the abattoirs and the only criterion of the time of ovulation in the abattoir animals is the appearance of the ovary by direct inspection Dannereuther states that only one of the several drug firms who place ovarian products on the market would affirm that their corpus luteum preparations are made from the corpus luteum of pregnant animals. There exists, at present, another serious source of error or cause of discrepancies in therapeutic effects in the usual practice of removing fats or lipoids from the dried products or solutions of such organs as the ovary, the hypophysis, and the adrenal cortex *The solvents that remove the lipoids may also remove the hormones* Until the hormones have been actually isolated it would seem more promising to use the entire gland, at least when given by mouth

Clinical Control in Use of Organ Extracts—In case of the endocrine glands in which organotherapy is still in the balance the clinical use of organ extracts should be most rigidly controlled and should be preceded or paralleled by animal experiments

Empirical organotherapy is not to be condemned entirely, but when organ extracts are used in this way without the guidance or positive indications from physiology or pathology, medical progress demands that other factors be eliminated so far as possible, so that the results may have some meaning A careful perusal of the literature will convince any candid man that we are great sinners in this regard The other factors we refer to are (1) other therapeutic measures such as changes in diet, occupation, environment, etc, simultaneously instituted, (2) the element of suggestion and (3) the natural history of the malady For example, if we disregarded the natural course of colds, or mumps, or chorea, we could readily establish a splendid organotherapy of these diseases This is too obvious to mention, except for the fact that our literature demonstrates that it is so frequently forgotten Our age has been characterized, medically, as one of therapeutic nihilism On the contrary, *in the field of internal glandular diseases and organotherapy it is an age of therapeutic credulity and foolish faith in the biological and medical omniscience of drug manufacturers*

The ideal scientific control is not easily attained in most clinical cases There are the spontaneous fluctuations in the severity of symptoms, spontaneous repair, irrespective of all therapy, and factors of general hygiene and nutrition which the good physician always endeavors to improve There are the uncertainties of diagnosis in all border line cases, especially in the so-called pluriglandular diseases Hence the value of the guide and aid of definitely controlled animal experiments Clinical results will ever constitute the final test of organotherapy in any given condition, but in

practice rather than medical practice. The combined administration of extracts of organs of known or probable endocrine functions as empirical *therapy is based on the following considerations*

1. There is some evidence of mutual interdependence of some of the endocrine glands. Thus the normal functioning of the gonads depends among other things on the thyroids and possibly the hypophysis and the adrenal cortex while extirpation of the gonads leads in some species to changes in the hypophysis, thymus, and the adrenals.

2. *Endocrine glands, like the thyroids or the pancreas that have* fundamental influences on the general metabolism and growth, will necessarily influence the other glands as well. Apart from this type of facts, the theories of specific influence (stimulation or inhibition) of one gland on others rest on precarious *foundations*. But it is quite probable that conditions like dietary deficiencies and chronic or acute infections have some effects on the entire endocrine system and more so on some than on others.

3. The above consideration has led to the theory that endocrine disorders are seldom if ever confined to single systems, that they are in fact, pluriglandular. The corollary to this theory is the pluriglandular *therapy of these diseases. But it must not be forgotten that in the experi*mental animal specific diseases are produced by damaging specific glands of internal secretion and so far as organotherapy is at all effective it suffices to administer the product of the damaged gland to control the disease. It is not necessary for example to add pituitary gonad or adrenal cortex to the thyroid extract to control experimental cretinism or myxedema.

4. Fortunately, *to date most* pluriglandular therapies have been administration of the mixtures by mouth. In this way the least damage is done to the patient. But the specious theory that we can supply the human body with any quantity and quality of endocrine pabulum the *internal* coordination being so perfect that the body cells pick out only the kind and quantity of hormones needed is not only without basis in demonstrated facts, but is in some instances (as the thyroid and possibly the hypophysis and the pancreas) definitely contradicted. The fact that most of the endocrine products are more or less inert when taken by mouth probably explains much of the success of the pluriglandular therapy in the hands of the uncritical.

5. But you say, *all these considerations and objections to pluri*glandular therapy are academic and beside the point. The whole matter is: Does the patient improve or get well on that is because of the pluriglandular diet? Yes that is the nub. We can throw the rationale *of the therapy to the wind* provided the patient improves and does not relapse when he receives our bill. All systems of healing point to suc-

in metabolism, slight mental retardation or inferiority, etc, may lie entirely outside the endocrine field, and it is now claimed by some that both hyperthyroidism and hypothyroidism may be present in persons who have a normal basal metabolic rate Early diagnosis becomes, therefore, essentially guesswork, and the meaning of positive results of organotherapy based on a guessed diagnosis become also a matter of guess This is undoubtedly one of the most disturbing factors in evaluating the results of organotherapy at present *How are we to proceed with fairness* in face of the following facts?

1 None of the *incipient symptoms* of endocrine hypofunction are specific

2 Slight hypofunction of any one of the endocrine glands may be only temporary, with spontaneous recovery Any therapy of such conditions is apt to lead us to wrong conclusions, and thus impede the progress of medical art and science

3 Prolonged and marked hypofunction of at least some of the glands of internal secretion (for example the thyroids, parathyroids, pancreas) may induce a more or less irreversible pathology in other organs, rendering late therapy less effective

What is the doctor to do in this dilemma? Is he to apply an indiscriminate or pluriglandular therapy in incipient and uncertain cases, on the chance of a random hit, or is he to await developments, thereby possibly harming the patient?

It would be presumptuous for any one man to dictate the line of conduct here, but I think the following points are within reason

1 When the diagnosis is a guess, let us all admit that the meaning of therapeutic results is also a guess

2 Internists as well as laboratory men should make greater efforts to work out reliable criteria of incipient endocrine hypofunctions, and determine more clearly the time factor of the irreversibility of endocrinopathic sequelæ

Uniglandular *versus* Pluriglandular Organotherapy—In recent years there has been a tendency to abandon *the use of single gland products* in favor of gland mixtures This tendency has been particularly marked in the case of the thyroid, the hypophysis the gonads and the adrenal cortex We do not include here the extreme tendency in this direction—the inclusion in organotherapeutic mixtures of extracts of organs (like the kidney, the lymph gland, the spleen, the brain etc)—where evidence of endocrine function is entirely lacking and the use of these mixtures as general or 'supportive" therapy for all kinds of disorders This is quack

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Uniglandular *versus* Pluriglandular Organotherapy—In recent years there has been a tendency to abandon the use of single gland products in favor of gland mixtures This tendency has been particularly marked in the case of the thyroid, the hypophysis the gonads and the adrenal cortex We do not include here the extreme tendency in this direction—the inclusion in organotherapeutic mixtures of extracts of organs (like the kidney, the lymph gland, the spleen the brain, etc)—where evidence of endocrine function is entirely lacking and the use of these mixtures as general or "supportive" therapy for all kinds of disorders This is quack

The clinician, on the other hand, perhaps knowing less intimately the evidence for the unity of life and organ function in mammals, is apt to become impatient with the strictures of the laboratory worker, and under value the significance of experimental data in the analysis and cure of human ills 'After all,' they say, the final arbiter is the crucible of the clinic" But in so far as the clinic is or can be a crucible it is identical with the crucible of laboratory research and it is only after repeated refining that either crucible yields pure gold The following seems obvious (1) certain nervous manifestations of endocrine pathology, especially in the group of consciousness, may differ in man and the dog and the laboratory man must admit that conscious nervous manifestations cannot at present be studied with accuracy in the experimental animal For example there is nothing definitely known in the spayed bitch identical with the neurocirculatory disturbances of the spayed woman When the internist reports that these neuroses of the premature menopause in his patients are ameliorated by ovarian therapy, the laboratory man has nothing to say except the very obvious remark that nervous symptoms, especially in women, are often profoundly influenced by suggestion. The menstruation phenomena in women are not completely duplicated in the rut of the lower mammals But as regards the other really objective findings of gonadectomy and gonad therapy after castration there is no quarrel between the clinician and the physiologist.

Both groups must also admit the *possibility* of differences in actual physiological effects of organotherapy *per os* in man and the laboratory animals As pointed out above, hormones given by mouth must pass the following obstacles before reaching their field of action (the blood and tissues) the destructive action of the digestive juices the destructive action of the intestinal bacteria, and exclusion or destruction by the intestinal mucosa So far as we know the digestive ferments are identical in all mammals but there may be species differences in intestinal flora and intestinal permeability Such differences however, must be demonstrated, not merely assumed

A Complete Organotherapy Probably Not Attainable—In the normal animal, hormone equilibrium is balanced by delicate chemical and nervous processes When this equilibrium is upset by disease, it is probably impossible to restore complete balance by our relatively crude methods of organ extract administration It must not be forgotten, however, that we are aided by the wonderful plasticity and capacity for readjustment on the part of the organism at least under many conditions Even our most successful organotherapy (the thyroid) is merely a physiological *control not a cure* for when the therapy ceases the malady returns When the malady does not return sooner or later when the organotherapy is stopped, we have merely tided the patient over a period of temporary depression of the gland involved a form of gland "rest cure"

cessful cures, to the crucible of their clinics But will you not agree that we must examine the crucible? Pluriglandular therapy as frank empiricism is not to be wholly condemned, even in the twentieth century But it increases the chances for *post hoc* fallacies, as few men are content to be mere puppets to the detail man We try to think, at times

It is, perhaps, significant that thyroid extract (the one substance active *per os*) is so frequently an ingredient in the ready-to-serve pluriglandular mixtures, just as alcohol and laxatives make up part of many otherwise inert patent medicines For example, one manufacturing concern lists ten different pluriglandular mixtures, and seven of these are said to contain thyroid extract

"Orthophrenic" (thyroid, pineal, testes-ovary prostate, cerebrospinal substance, activating substances)

"Virilogenic" (anterior lobe, adrenal cortex thyroid testes, prostate activating substances)

"Galactagogue" (mamma, placenta, posterior lobe, thyroid, activating substances)

"Morphogenic" (thyroid, adrenal, pituitary, pineal, thymus, activating substances)

"Catabolic" (thyroid, posterior lobe, adrenal medulla, sperminum, activating substances)

"Feminilogenic" (pituitary, adrenal, thyroid, corpus luteum, ovary mamma (virgin), activating substances)

"Osteoplastic" (thyroid, pituitary, parathyroid, adrenal medulla, thymus, activating substances)

We are not informed what the "activating substances" are, except in the case of the thyroid, where it is said to be iodids The use of these mixtures thus amounts practically to dosage of the patient with thyroid extract and potassium iodid

Experimental *versus* Clinical Organotherapy—Despite the minor difference in species in the kind and severity of symptoms induced by specific endocrine pathology, and minor species differences in the effects of organotherapy, it is a striking thing that in all securely established facts of endocrine diseases and therapy, there is a practically complete parallel between the experimental mammal and man We need mention only the thyroids, the parathyroids, the gonads, the pancreas This fortunate fact rendered possible the rapid advance in the analysis of endocrine diseases in the last fifty years This fact also tends to render the laboratory investigator skeptical in relation to therapeutic results on man that cannot be duplicated in the laboratory, especially if the clinical reports include such variables as guessing the diagnosis several synchronous therapies, and inadequate controls in the way of the natural history of the disease

In the adult normal animal the thyroid is made up of acini of cuboidal cells with the thyroid colloid filling the center of the lumen In mammals this adult structure begins to appear at or a little before birth In early intra uterine life there is no colloid or definite arrangement of the cells into acini

The colloid is obviously a cell product (cell degeneration or cell secretion) But its relation to the gland function is not yet clear Bensley has succeeded in staining an intracellular thyroid colloid This colloid is most abundant in the region of the cells adjacent to the lymph vessels and blood vessels It is usually held that the colloid in the lumen of the acini represents a storage state of the physiologically important internal secretion which according to the needs of the body becomes changed, is reabsorbed by the cells and passes into the blood stream

The blood and lymphatic supply to the thyroid is very abundant so that the blood flow through the gland per mass of tissue is greater than in any other organ in the body Manley and Marine have shown that a piece of thyroid transplanted in other regions of the body stimulates the *development of a similar extraordinary blood supply The great vas*cularity of the thyroid is therefore intimately related to its specific function

Significance of the Thyroid Innervation —Branches from the cervical sympathetic nerves pass along the thyroid vessels to the gland These thyroid nerves have with certainty a vasomotor function Their stimulation causes primary vasoconstriction of the gland and this is followed by vasodilatation at the end of the stimulation The question whether there are also true secretory fibers in the thyroid nerves has been attacked by diverse methods without as yet yielding conclusive results Asher and Flack, also Ossakin report that stimulation of the thyroid nerves increases the excitability of the depressor reflex mechanism due to an increased thyroid secretion thrown into the blood Rabe *et al* found that the stimulation of the nerves reduces the iodin content of the gland and this was confirmed by Watts but the latter investigator also found that identical decreases in iodin were induced by mechanically produced circulatory changes (temporary vasoconstriction) in the gland Watts findings are questioned by Van Dyke Cannon reports that a successful union of the phrenic nerve with the cervical sympathetic induces some of the symptoms (nervousness exophthalmos increased metabolism) of thyroid hypersecretion owing to the continuous respiratory nervous discharges from the phrenic acting on the gland cells The fact itself is contradicted by Troell but if it shall be proved correct as reported by Cannon, the excessive thyroid activity may be due to circulatory rather than secretory nerve disturbances Cannon also finds that stimulation of the thyroid nerves produces an electrical change in the thyroid similar to that induced in muscle or in nerve when thrown into activity This

THE THYROID

The employment of thyroid in human medicine in cases of congenital absence, atrophy, or destructive lesions in the gland is a typical case of hormone therapy *It is also in reality our only well established case of successful organotherapy* The marked result with this organ has been the main impetus and guide in the attempts to work out an organotherapy for the other endocrine glands The thyroid produces a substance or substances of specific physiological importance, stable *in vitro* not destroyed by the digestive juices or the bacteria of the alimentary canal, and absorbed in active form into the blood The functions of the gland may be partly replaced by the administration of the gland So well established is this principle that conditions of the thyroid can be diagnosed *in part from the effects on the body of the administration of the gland*

The administration of the thyroid in organotherapeutics is based partly upon clinical and partly upon experimental work The latter preceded the former, but the two methods have been closely combined, each reacting upon the other The gland was not employed in medicine until a rational basis for its use had been established experimentally, empiricism had no part in its introduction

The most important steps in our knowledge of the thyroid are the following (1) the demonstration (by Schiff, Riverdin, Kocher, and others) that extirpation of the thyroid in adults leads to a series of disturbances designated by the term *cachexia strumipriva* or myxedema, (2) the experimental production of cretins by removing the thyroid in young animals, and the recognition of sporadic and endemic cretinism in man as due to hypothyroidism, (3) the demonstration that the symptoms of hypothyroidism can be partly controlled by thyroid administration (Ewald, Baumann Magnus Levy, Pick and Pineles, Murray Howitz, Mackenzie, Fox, Kocher, and others), (4) the discovery of the thyroiodin and the subsequent studies of specific thyroid chemistry (Baumann, Oswald, Hunt, Marine, Koch, Kendall) (5) the demonstration of a relation of thyroid physiology to the diet (Watson, Hunt, Marine, Burget, Bensley) and possibly to infectious processes (McCarrison Rosenow), (6) the studies of the possible control of thyroid activity through secretory nerves and circulatory changes (Asher, Watts Cannon, and others)

From the standpoint of clinical medicine some of the most important problems in thyroid physiology remain yet unsolved, namely, *the cause and significance of the thyroid changes in so called toxic goiter in man and the cause of endemic goiter*

Function of the Thyroid—The thyroid develops from the epithelium of the branchial clefts of the embryo The embryological anlage of the thyroid is thus similar to that of the parathyroids and the thymus gland

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he interprets as proving a direct secretory nerve action However, Schafer has reported similar electrical changes in the mammary gland on injection of pituitrin, and it is now demonstrated that pituitrin causes, not milk secretion, but merely a discharge of the milk present in the duct systems by contraction of the duct musculatures Moreover, the electrical response in the thyroid, as reported by Cannon, was sometimes positive and sometimes negative It does not seem possible at present to interpret both of these effects as due to an increased secretory activity Moreover, denervation of the thyroid in normal animals does not produce hypothyroidism, and transplanted fragments of thyroid appear to function in a normal manner without nerves Cannon, *et al* also report that stimulation of the thyroid nerves leads to a temporary acceleration of the denervated heart They interpret this heart acceleration as due to an increased thyroid secretion This interpretation is at present open to question

If secretory nerves are present they are certainly not necessary for the normal gland function The control of the gland activity is, therefore, essentially a humoral one, as indicated by the great vascularity But the question of thyroid secretory nerves is, nevertheless, one of great practical importance in relation to the cause and control of possible hyperthyroidism

Chemistry of the Thyroid—The older investigators reported the presence in thyroid of albumins, nucleoproteins, albumoses, leucin, xanthin, hypoxanthin, lactic and succinic acids, etc In glands which have undergone cystic degeneration the finding of mucin, cholesterin, methemoglobin, bile pigments etc, is reported

Iodin—Since the discovery, in 1895, by Baumann, of iodin in the thyroid, interest in the chemistry of the gland has centered largely around this element, and the substances with which it is in combination

The amount of iodin in the thyroid, not only of man, but of the lower animals is extremely variable, being influenced by age, character of the food locality, the physiological conditions of the thyroid and many other for the most part unknown, factors The thyroids of infants and of newly born animals contain less iodin than adult thyroids, in fact, it cannot be detected at all in many cases at least not by the use of usual quantities of the gland, and by the usual methods But the same is true in many instances of the thyroid of adults and, to all appearance, normal animals Aschbacher gives the average amount of iodin in the human thyroid between the ages of twenty five and thirty as 8 98 milligrams, it is less both in youth and old age The percentage based on the weight of the dry gland varies from 0 to 0 4 or 0 5 Extreme variations both in the total amount and in the percentage occur The thyroids of salt water fish contain three times the amount of iodin usually present in the mammalian thyroids In some of the marine invertebrates iodin

is present in greater quantities in some of the cutaneous and excretory structures where the iodin cannot have the physiological significance it has in the thyroid of the vertebrates

The nature of the physiologically active iodin complex in the thyroid is unknown, notwithstanding the large amount of work which has been devoted to the problem The form is specific for the thyroid no other iodin compound is known which has the specific physiological properties of the thyroid substance or hormone (von Furth Schwartz Koch Mac Lean Hunt and Seidell) It is known to be united in some way to the proteins probably to one or more of the amino acid constituents of these (Koch, Kendall, Cameron)

Baumann isolated a specific but ill defined iodin compound from the thyroid one which has at least many of the specific properties of the gland substance itself He named this substance "iodothyrin"

Oswald isolated, at least approximately the protein with which the iodin is combined He named this protein 'thyroglobulin' it was found to constitute one-third to one-half or more of the weight of the dry gland The iodin content varied from 0 to 0 86 per cent or more Oswald believed this thyroglobulin if it contained iodin, to represent the true active principle of the thyroid, Baumann s iodothyrin could be obtained from it by hydrolysis

Oswald also isolated an iodin free protein having the properties of a nucleoprotein but this protein did not have the characteristic physiological thyroid action

F C Koch found that as determined by the acetonitril test of Hunt the thyroglobulin as well as the metaprotein fraction of the thyroid retained the full physiological activity of the entire thyroid Further hydrolysis into iodothyrin and primary or secondary albumoses shows a gradually decreasing activity, while the amino acid fractions show little or no physiological activity although they retain some of the iodin The thyrometaprotein of Koch contains three times the percentage of iodin found in the entire thyroid yet it shows no greater physiological activity than the dried thyroid The relation of the iodin to the physiological activity of the thyroid thus appears to be a direct one Hunt has reported that Kendall s thyroxin is less effective than ordinary dried thyroid as determined by the acetonitril test

Thyroxin —Kendall has isolated and analyzed a crystalline compound ($C_{11}H_{10}O_3NI_3$) from the *thyroid having three molecules of iodin fixed* in a protein derivative almost identical with tryptophan This substance is called 'thyroxin ' Kendall thinks it is the active thyroid hormone On the whole the action of thyroxin parallels that of crude thyroid extract in man and animals that have some thyroid gland left It has not been proved that thyroxin is effective in absolute cretinism. This would be the crucial test of the true hormone nature of thyroxin The thyroxin

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ologically active thyro-iodin compound Possibly the thyroids may store iodin outside of this compound, for example in the colloid Kendall has obtained inactive iodin fractions from the thyroid

Several writers have called attention to the variation in the iodin content of commercial thyroid preparations Hunt and Seidell found the preparations on the American market to vary from 0 095 to 0 38 per cent The average was approximately 0 2 per cent

It is thus evident that the commercial preparations vary by as much as 400 per cent Such variations in the strength of most drugs would be considered intolerable and there can be little doubt that more satisfactory therapeutic results would often be obtained if the thyroid preparations were more uniform in strength That lack of uniformity does not cause more inconvenience is due largely to the fact that thyroid medication must, by its nature be peculiarly individual the dose must be governed by the degree of thyroid deficiency of the patient and this can only be determined by trials with different doses[1] When however, the proper dosage of a certain preparation in an individual case has been determined, it would be distinctly advantageous to be able to continue the same dosage if a fresh supply were prescribed At present even if the same firm s preparation were prescribed the second order might be several times as active as the first Hence, it would be very desirable for the pharmacopeia to fix a standard iodin content for the official preparation a standard of 0 2 per cent would seem reasonable (Hunt and Seidell) This iodin content must, of course represent the physiologically active thyroid substance and not the addition of other organic or inorganic iodin For that reason the chemical standardization by means of the iodin percentage should be supplemented or controlled by physiological standardization (the acetonitril method of Hunt, the cretin method of Basinger or quantitative determination of the thyroxin content)

The iodin in the thyroid is both in the colloid and in the cells There is a fairly uniform ratio of distribution two-thirds being in the colloid and one-third in the cells (Tatum Van Dyke)

Relation of the Thyroid to Diet —It has been shown by Watson and Burget (on the rat), Marine and Lenhart, and Gaylord and Marsh (for the salmonoid fishes) and Bensley (for the opossum) that a high or otherwise abnormal protein diet induces thyroid hyperplasia and marked enlargement of the gland But this appears not to be true for the guinea pig (Loeb) In the case of the brook trout this hyperplasia followed feeding with mammalian liver or uncooked animal protein and was promptly stopped by feeding with fish or cooked meat McCarrison was able to induce thyroid hyperplasia in rats by feeding extracts of feces

[1] I have met with one case of hypothyroidism with intense intolerance to any form of thyroid medication This is therefore a factor in dosage in rare instances — Editor

can be given hypodermically or intravenously. As measured by the effect on the basal metabolism on hypothyroid patients, the influence of a single injection of thyroxin is in evidence from four to seven weeks after an initial latent period of two to four days. The quantity of thyroxin obtainable from the thyroid is very small. Not all the iodin in the thyroid appears to be combined with thyroxin. Kendall *estimates that there are* 14 milligrams of thyroxin in the body tissue (man), exclusive of the thyroid. Plummer estimates that the normal human adult uses up from 0.5 to 1.0 milligrams thyroid hormones per day. Hence, the normal thyroid secretion should be at that rate.

Relation of the Iodin to Physiological Activity of the Thyroid.—Baumann's discovery of iodin in the thyroid stimulated an immense amount of work and led to the accumulation of a large number of facts as to the occurrence of iodin in the thyroid of various animals, and in that of man, under various conditions, both pathological and normal. *The fact that iodin can frequently not be detected in the thyroids of healthy* individuals has led many to doubt whether this element is a necessary or important constituent of the gland (cf. Hunt and Seidell, Carlson and Woelfel). From almost the beginning there has been evidence, not very conclusive, however, that the activity of the thyroid when used as a drug is closely dependent upon its iodin content. Thus, Roos in three experiments upon dogs found that more nitrogen was excreted after the administration of thyroid rich in iodin than after that of thyroid containing little iodin. Oswald, in two experiments, also found thyroglobulin rich in iodin to cause a greater excretion of nitrogen than did thyroglobulin poor in iodin. Marine and Williams found in two experiments *that feeding* thyroid containing a larger percentage of iodin caused a greater loss of weight in dogs than did a preparation containing a smaller percentage.

Hunt and Hunt and Seidell, in extended series of experiments, in which the effect of thyroid upon the resistance of animals to certain poisons was determined, found a *close parallelism between the physiological* activity of the thyroid and the iodin content. They also found that the iodin which accumulates in the thyroid after feeding iodin compounds is present in an active form, that is, in the form characteristic for the *thyroid. In the same species large thyroids (goiter) contain a smaller* percentage of iodin than *small thyroids, and correspondingly expressed* juice from large thyroids exhibits less physiological activity than that from small thyroids.

Although further clinical tests are desirable, the above experiments offer almost conclusive evidence that *the therapeutic value as well as the toxic action of thyroid preparations is directly proportional to the iodin content* (Kocher). It is well established that feeding iodin in any form leads to a rapid increase in the iodin in the thyroid, but it is not known whether the iodin thus stored is immediately incorporated as the physi-

blood of thyroidectomized cats yields a positive acetonitril test—a fact which seems to question the validity of the test itself

Basinger repeatedly transfused blood of normal rabbits into cretin rabbits without observing any effects on the cretin conditions but when similar transfusions were made into the cretins of blood from rabbits fed varying quantities of commercial thyroid the cretin condition was influenced in the same manner as by feeding thyroid

It is altogether probable that the thyroid secretion is present in normal blood, but in too small concentrations for detection This is indicated by some work of Woelfel and Luckhardt These investigators find that when blood from dogs with high iodin content of thyroid is transfused into dogs (previously bled dry) with low iodin content of the thyroid the percentage of iodin in the thyroid of the latter is increased This seems to show that there is a balance or equilibrium between the stored thyroid secretion in the gland and the circulating thyroid secretion in the blood This gives us hope that the question of thyroid secretion in the various types of thyroid hyperplasia may yet be solved by blood analysis The presence of thyroglobulin in lymph and blood coming from the thyroid gland has recently been demonstrated (Hektoen and Carlson)

Relation of the Iodin to Histological Structure of the Thyroid—If iodin is a necessary constituent for normal thyroid function it would seem that it would be equally necessary for normal thyroid structure Nevertheless in exceptional cases in most animals and as a rule in some species, iodin in structurally normal thyroids is either absent or so small in amount that it cannot be demonstrated by our best chemical tests The most significant findings in the relation of the iodin to thyroid structure are the observations of Marine Bensley Loeb and others namely that most types of thyroid hyperplasia can be arrested and converted into a colloid or resting state by the administration of iodids in any form It is now generally agreed that the simple thyroid hyperplasia of endemic goiter, adolescence, etc can to a large extent be prevented or controlled by small quantities of iodids We are not permitted to conclude from this fact that the hyperplasia which is controlled in this way is due to lack of iodin in the food or in the body This arrest of hyperplasia may be a drug action of the iodin, or an evidence of a detoxicating role of the thyroid, as suggested by von Cyon the excess of inorganic or toxic iodin being converted by the thyroid into a non toxic or less toxic form According to Bensley, the thyroid hyperplasia induced in the opossum by excessive *protein diet is not arrested by iodids.*

According to Jones and Jones and Tatum, increasing the iodin content of the thyroid increases the stainability of the thyroid colloid so that the amount of iodin in the gland can be in part determined by the reaction of the colloid to Mallory s connective tissue stain

The specific affinity of thyroid tissue for iodin is retained in certain

from goiter patients But we are not permitted to generalize from these observations, although they are both interesting and important, for high protein diet, or feces from goiter (toxic) patients fails to induce these thyroid changes in other species (cat) Evidently the thyroid stability or factor of safety varies greatly in different species

Feeding meat is said to reduce the iodin content of the thyroid This may be a factor in the hyperplasia

Feeding thyroid, food rich in iodin or iodids, tends to increase the colloid in the thyroid, as well as the total iodin content in the gland Thyroids in the process of compensatory hypertrophy seem to form an exception (Loeb)

Hunt found that mice fed on oatmeal or on oatmeal and liver showed a much greater resistance to acetonitril than mice of the same litter fed on eggs, crackers and milk He ascribes this difference to a greater *stimulating action of the oatmeal and the liver diets on the thyroid* gland

Prolonged starvation or vitamin A free diets lead to degeneration and atrophic changes in the thyroid (Jackson, Tsjuji)

Secretion *versus* **Detoxication**—Bensley and others claim to have identified the thyroid secretion in the cells by microchemical methods much in the same way as the secretion granules or pro ecretion of the digestive glands have been brought out by staining But the presence of the secretion as a normal element in the body fluids has not been demon strated Our strongest evidence that the thyroid works by the mechanism of an internal secretion rather than by processes of detoxication is the result of thyroid organotherapy in experimental and clinical hypothyroid ism These results are capable of no other interpretation But this does not exclude detoxication processes in the thyroid, in fact von Cyon s theory is partly true Because of the special affinity of the thyroid for iodin, iodin compounds of all kinds—including the more or less toxic in organic iodids—are taken out of the body fluids and turned into the less toxic thyroglobulin But this work can be performed by the kidneys as an elimination process, and at any event it is of secondary importance in thyroid physiology for much of the thyroid function can be taken by the dried and dead thyroid product.

The Thyroid Secretion and Body Fluids—Probable as it seems from experimental and clinical data that the normal thyroid yields a secretion to the body fluids, yet it must be admitted that this secretion has not yet been demonstrated in the blood or the lymph, even in the lymph taken directly from the thyroid gland The colloid observed, by histological methods, in the thyroid lymphatics is probably an artefact The acetoni tril test on normal blood of men and animals is negative (Hunt, Carlson and Lussky) Even in cases of blood from exophthalmic goiter patients the method yields inconclusive results Trendelenburg reports that the

women there frequently occurs what may be called a strictly physiological hyperplasia at puberty, at menstruation and during pregnancy although some of the enlargement of the thyroids at these periods may be simply due to increased vascularity The period of active growth of simple or benign goiter is really a period of hyperplasia According to Marine a colloid goiter represents a relatively resting stage of a previous hyperplasia. Finally in so-called toxic goiter or Basedow's disease, there is usually proliferation of the thyroid cells increase in gland volume and gland vascularity with decrease in gland colloid It may be considered as a general rule that the amount of colloid in the thyroid is inversely proportional to the rate of cell division and growth of the gland at any period

In moderately severe cases of Graves disease Geyelin reports that 70 per cent of his cases showed a lowered sugar tolerance Milder cases have normal blood sugar Feeding thyroid to myxedematous patients may induce hyperglycemia

It must be noted in the first place that mere increase in cells and gland volume does not mean increased activity or increase in the secretion A mere fraction of the normal thyroid suffices to meet the normal needs of the organism This means that the thyroid under normal conditions does not work up to full capacity hence it should be possible to increase greatly the rate of thyroid secretion without increase in the number of cells If, as seems probable, the thyroid activity is governed mainly by the blood, doubling the thyroid volume would no more increase the thyroid secretion than doubling the kidney volume would increase the quantity of urine The reverse experiment has not been made but we predict that when made that is when two healthy kidneys are successfully implanted say on the carotids in the neck the sum total of the urine secreted by the four kidneys will be no greater than that secreted by animals own kidneys before the implantation.

In the second place gland cells in condition of active division and proliferation are probably not sufficiently differentiated to perform a highly specialized function And in the third place, we have as yet no reliable test histological physiological or chemical for the rate of thyroid activity at least covering longer periods than ordinary crucial experiments Yet the commonly accepted theory to-day is that of Mobius namely, that the thyroid hyperplasia in toxic goiter represents thyroid hypersecretion and that the hypersecretion is responsible for the toxic symptoms

This last theory is based mainly on three lines of evidence (1) symptoms similar to the syndrome of toxic goiter are produced in man by excessive thyroid administration, (2) patients with toxic goiter appear on the whole to be excessively sensitive to thyroid administration (3) in many cases the symptoms of toxic goiter appear to be at least partly

stages of malignant growths of the thyroid, primary and secondary Whether the iodin complex in these thyroid tumors represents the active thyroid hormone has not yet been established

Sweet and Ellis report that *removal of the external function* (pancreatic digestion) of the pancreas leads to an increase of iodin and colloid in the thyroid glands

Relation of Thyroid Hyperplasia to Thyroid Neoplasm—Thyroid hyperplasia predisposes to thyroid neoplasm In dogs, malignant growths of the thyroids with typical bone, lung, and liver metastases are not infrequently found on the basis of an old goiter We have never seen them start from a normal thyroid *Regenerating thyroid tissue* (compensatory hyperplasia) may show powers of invasion like cancer (Loeb)

The line of demarcation between simple hyperplasia and malignancy would seem to be metastatic growth Yet, something like metastatic spreading growths appears to be a normal phenomenon in the thyroid of fishes, where the glands are not surrounded by a connective tissue capsule (Gudernatsch) This has led to contradictions and confusions in the interpretations of the thyroid hyperplasia or thyroid cancer so common in salmonoid fishes, especially under domestication Marine and Lenhart regard these thyroid growths as simple hyperplasia, since they respond to the same measures that modify simple thyroid hyperplasias in mammals Gaylord and Marsh, on the other hand, regard all stages of this hyperplasia as malignant neoplasm This appears to the writer an extreme position If this view is tenable for fish, it should be equally tenable for mammals, in which case thyroid hyperplasia in man and other mammals becomes a cancer problem Gudernatsch has pointed out that the metastases of normal fish thyroids do not cause destruction of adjacent tissue The same is certainly true for simple thyroid hyperplasia in the higher animals At the same time malignancy in the primary thyroid tumor is probably present sometime before metastatic growth occurs, so that a sharp line between simple hyperplasia and malignancy of thyroid growths cannot be drawn

Hyperthyroidism, Experimental and Clinical

Toxic Goiter—The effects of hypothyroidism experimental and clinical, are clear and their control is partly in our hands through organotherapy This cannot be said of the causes and effects of hyperthyroidism —if, indeed, there is such a thing as continued hyperactivity of the thyroid with attendant symptoms of disease Hyperplasia of the thyroid gland occurs in man and animals under many conditions We have seen that in some animals it may be experimentally induced by the diet In

Some malignant growths of the thyroid are associated with the clinical picture of exophthalmic goiter —Editor

bound up with the question of the cause of the hyperplasia It will probably be found that we are dealing with a complex of causes (abnormal diet deranged metabolism specific and non specific infections nervous disarrangements, etc) That the hyperplasia in experimental animals is primarily due to changes in the blood appears to be shown by the experiments of Manley and Marine The transplant of a normal thyroid into an animal with active thyroid hyperplasia becomes hyperplastic, and vice versa Pups from bitches with active thyroid hyperplasia are born with hyperplastic thyroids or goiter (Carlson)

The interpretation of the nature of thyroid hyperplasia in toxic goiter is further complicated by the fact that, in many of the lower animals thyroid hyperplasia, histologically identical with that of toxic goiter in man is present without any other of the Basedow s syndrome In fact spontaneous Basedow as well as spontaneous cretinism is very rare, though apparently not unknown, in animals below man

The justification for this rather lengthy discussion of hyperthyroidism in a chapter on Organotherapy is our desire to point out that the existence of actual thyroid hypersecretion with consequent symptoms of disease is still in question, also that it behooves clinical and laboratory workers to test anew prevalent theories in the hope of reaching a clearer knowledge and a better control of a very serious malady be it through organotherapy or other measures

According to Marine and Baumann the excessive metabolism and fever following removal or serious trauma to the adrenal cortex is prevented by thyroidectomy It this is true it would seem that the thyroid gland is at least temporarily disturbed (increased secretion) directly by the withdrawal of the adrenal cortex hormones or by toxins produced in other parts of the body in the absence of adrenal cortex function.

Hypothyroidism in Childhood

Cretinism—The most marked effect of the removal of the thyroid in young animals and of its atrophy or injury in children is a cessation of growth and development both physical and mental The changes in the skeleton are especially marked there is a cessation or retardation of the normal ossification of the cartilages The epiphyseal ends of the long bones grow slowly, while the periosteal ossification may be normal or in excess The extremities are relatively short and thick the pelvis is small This condition and the muscular degeneration are responsible for the protruding abdomen Abnormalities in the growth of bone are largely responsible for the characteristic shape of the skull and thorax in cretins

If the thyroid deficiency does not occur until rather late in childhood the above changes may be absent, and the hyperthyroidism may be evident only in a cessation of normal growth

controlled by surgical and medical measures that reduce the thyroid volume and presumably the thyroid activity

The most striking symptom of toxic goiter is the greatly accelerated metabolism DuBois, Plummer and Boothby, Means, and others have shown that in severe cases this may be increased 75 per cent above normal, and an increase of 50 per cent in moderately severe cases is not uncommon In mild cases the state of metabolism may be practically normal DuBois thinks that some of the other symptoms (tachycardia, high blood pressure, high temperature, nervousness) are in part secondary effects of augmented metabolism with the attendant increased production of heat DuBois also showed that there is no conservative form of treatment of toxic goiter that reduces the metabolism rate to any greater degree than mental and physical rest These measures may lower the rate more than 10 per cent, while in some cases ligation of the thyroid arteries actually increased the rate of metabolism

Experimental hyperthyroidism has not yet been produced There is no evidence that the rat, fish, and opossum thyroids of Watson, Marine, McCarrison, and Bensley secreted in excess It is true that excessive thyroid feeding, especially in man, duplicates most of the symptoms of exophthalmic goiter, but the same effects would probably be produced by any other substance that had a similar effect on the metabolism rate It is biologically significant and clinically important that, of all animals so far studied man is the most susceptible to the deleterious effects of thyroid feeding The attempt of Cannon to induce hyperthyroidism by union of the phrenic and cervical sympathetic nerves has already been referred to

There are not wanting other interpretations of the nature of thyroid hyperplasia, especially in toxic goiter The most important are the perverted secretion theory and the compensatory hypertrophy theory, especially as elaborated and upheld by Marine According to Marine the hyperplasia in goiter is a response of the thyroid to an increased need of the body for the secretion in consequence of some disarrangement in the general metabolism, in fact, despite the increased secretion in toxic goiter, there may be an actual thyroid deficiency owing to the greater need for the secretion On this theory, there is room for at least a careful experimental thyroid organotherapy in toxic goiter, and, in fact, *favorable results from thyroid feeding in toxic goiter have been obtained by competent clinicians* If the thyroid hyperplasia of toxic goiter is not primary, but compensatory in nature, we expect thyroid feeding to reduce the hyperplasia Loeb has shown that the true compensatory hyperplasia following extirpation of the larger part of the thyroids is prevented by thyroid feeding It is not prevented by iodids, thymus, or tethelin feeding

The nature of the thyroid hyperplasia in toxic goiter is, of course,

Complete thyroidectomy in experimental animals appears to prevent sexual maturation entirely and thus leads to sterility

The cretin symptoms following complete thyroidectomy in the young but otherwise normal animal do not appear until late after the operation (three to six weeks or longer)

Spontaneous cretinism is rare in the lower animals In man it is sporadic as well as endemic and in either case it may be congenital or a matter of gradual development after birth (primary atrophy cystic or colloid degeneration) The physiological state of the maternal thyroid during gestation influences the thyroid of the fetus. Thus if the mother

FIG —SKIN LESIONS DEVELOPED IN THYROID FED ABSOLUTE CRETINS FIVE MONTHS AFTER DISCONTINUING THE THYROID TREATMENT (Basin r)

has marked thyroid hyperplasia during pregnancy the offspring is born with enlarged thyroid on the other hand simple colloid goiter in the mother has no influence on the fetal thyroids It is also reported that complete thyroidectomy in the mother leads to thyroid hyperplasia in the offspring

The thyroid hyperplasia of the young from mothers having active thyroid hyperplasia during pregnancy is probably not an instance of tru inheritance, but a matter of fetal environment The same conditions that induce the hyperplasia in the mother, acting through the blood produce the same effect on the fetus Hence it is primarily a humoral, not a nervous effect But there may also be true inheritance factors in both simple and toxic goiter

The hair on the pubis and in the axillæ is scanty or absent, and the sexual organs are poorly developed, while puberty, if it occurs at all, is late. The skin in children is often myxedematous. Metabolism is much depressed (Bergmann, Mansfield, DuBois), and the oxygen absorption and nitrogen excretion may be but one-half that of the normal.

It is difficult, however, to distinguish between primary and secondary effects of injuries to the thyroid. The latter cause marked changes in the nutrition and metabolism, and these may be the immediate cause of some of the abnormalities now ascribed to the direct influence of the

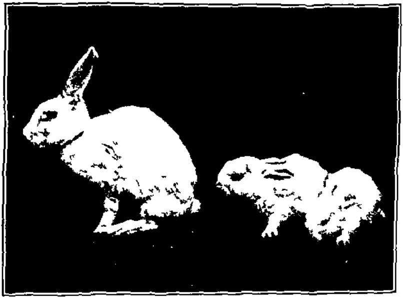

FIG. 1.—A NORMAL RABBIT AND TWO ABSOLUTE CRETINS FROM THE SAME LITTER. AGE THREE MONTHS. Control rabbit 1630 grams; cretins 760 and 840 grams. (Basinger.)

thyroid. There is evidence that hypothyroidism leads to increased growth of the hypophysis, the adrenals, and the islands of Langerhans in the pancreas. We cannot at present say whether or not these changes are compensatory in nature. The evidence seems to be to the contrary, at least as regards the changes in the hypophysis.

The effects of thyroid insufficiency upon mental development are no less striking than those upon physical development: the patients are apathetic, the expression is stupid, and idiocy frequent. There is evidence of degenerative changes in many of the organs and especially the muscle. The fatty degeneration of the muscle is, at least in part, responsible for the feeble heart, muscular weakness, and characteristic "pot belly." There is also decreased resistance to infection, and, strange to say, increased susceptibility to thyroid administration.

corpuscles are common. There is lowered resistance to infection. Metabolism may be depressed; carbohydrate tolerance is increased. Degenerative changes in the ovaries and testes have been described.

Thyroid Administration in Hypothyroidism.—The most marked effects of the administration of thyroid are seen in cases in which the thyroid is absent or deficient, and it is upon the results in such cases that the therapeutic use of thyroid is based. Fresh or dried entire thyroid has so far yielded as good or even better results than various isolation products of the gland, such as thyroiodin and thyroxin.

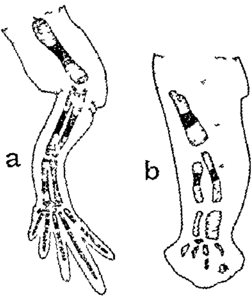

Fig. 3.—Thyroid Deficiency in the Tadpole. a, hind leg of normal tadpole (total length 5[illegible] millimeters, body length 23 millimeters) showing normal cartilage and bone formation. b, hind leg of thyroidless tadpole (total length 80 millimeters, body length [illegible]9 millimeters) showing defective cartilage and bone formation. (Terry.)

Administered in appropriate doses to cases of sporadic cretinism and infantile myxedema, there is at first a loss of weight with improvement of the skin. Cyanosis disappears and the blood becomes normal. Growth both bodily and mental recommences and may take an almost normal course. The hair grows rapidly and becomes glossy; the teeth and nails also grow. There is a distinct acceleration of metabolism. The mental improvement is most marked in young children. Similar results are obtained in cretinoid animals (Pick and Pineles, Bisinger and others).

In complete absence of thyroid tissue no amount or duration of thyroid administration will bring the final growth up to the normal. *Thyroid organotherapy is therefore not a complete substitute for the living organ.* This is not surprising in view of the extensive degeneration found in practically all the organs in absolute cretinism.

Many attempts have been made to stimulate growth in conditions other than cretinism by thyroid administration. Thus it has been extensively tried in idiots and backward children. It has been administered in cases of delayed union of fractures on the theory that it would hasten union by stimulation of the specific bone metabolism.

Hunter found that thyroidectomized sheep on starvation showed no starvation acidosis, but they excreted more nitrogen than the controls. They showed no diminished oxidation, at least as regards purin catabolism, but the sugar tolerance appeared to be increased Mansfield and Ernst state that there is no increased rate of protein catabolism in experimental fevers in thyroidectomized animals According to Herring complete thyroidectomy in cats and rabbits has no effect on the epinephrin content of the adrenal glands unless parathyroid tetany develops, in which case there is a decrease in epinephrin But in the cat, feeding large quantities of raw, ox thyroid increases the epinephrin content in the gland by more than a third, Miura states that thyroidectomy does not influence alimentary and phlorizin glycosuria in the animal, but diminishes somewhat epinephrin glycosuria Contrary to earlier reports (Lorand) thyroidectomy does not appreciably influence pancreatic diabetes Yuschemko has described certain changes in the phosphorus and lipoid content of the blood and organs after thyroidectomy in animals

Hypothyroidism in the Adult

Myxedema —Thyroid deficiency in the human adult is seen most typically in myxedema, which is characterized by physical and mental inertia, and by changes in the skin, depressed metabolism, etc The skin is white and thickened, due to the growth of granulationlike tissue and an infiltration with a substance resembling mucin, the secretions are scanty or absent, the skin becomes dry and rough, the hair falls out There are frequently abnormal sensations of taste, smell and hearing The temperature is subnormal and the pulse slow and weak There are diminished oxygen absorption and carbon dioxid secretion, there is a tendency to obesity, although the patients usually eat little The metabolism is depressed to a greater degree than in any other known condition

Lusk states that it is possible to explain the reduced temperature as due to disturbances in the nervous mechanism of temperature regulation, and that the lowered temperature may be an influence in reducing the metabolism of the cells The coagulation time of the blood is stated to be shortened (Lidskey)

The effect of thyroidectomy on adult animals is variable *True myxedema is rarely if ever developed* This leads one to question whether myxedema in man is pure hypothyroidism Monkeys do not show conditions analogous to myxedema in human beings, at least for months or years after the operation (Munk, Kishi, Vincent and Jolly, Halpenny and Gun) Many adult animals show little change after the removal of the thyroid, although eczema, conjunctivitis rhinitis and other indications of catarrh of the respiratory passages, and especially emaciation and diminution in the number of red and increase in the number of white

the urine. The consumption of oxygen may be increased 70 per cent. The temperature rises; the pulse rate is increased; there is usually a striking loss of weight due to the disappearance of the myxedematous infiltration and loss of fat. The entire metabolism is brought back to the normal level or raised slightly above the normal. The skin approaches the normal; sweating, which is usually entirely absent in myxedema, becomes possible. The hair grows again; menstruation reappears; the bowels become regular; the mental condition is much improved. These changes begin in three to four weeks with the usual doses of thyroid.

The first myxedematous patient treated with thyroid extract by Dr. Murray, beginning 1891, died in 1920. During these twenty-nine years

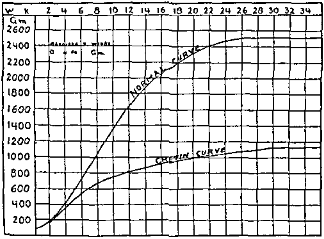

FIG. 4C.—Growth Curves of Four Normal Control Rabbits, Two Absolute Cretins and Six Absolute Cretins Transfused Repeatedly with Hyperthyroid Blood Serum. (Pa n r)

the patient enjoyed ordinary good health and the myxedema was kept under control by continuous thyroid feeding.

The marked change in the skin in cases of myxedema produced by the administration of thyroid have led to the extensive trial of this substance in other abnormal conditions of the skin.

Thyroid Feeding in Conditions of Mild Hypothyroidism.—In addition to the above conditions in which there is obviously severe thyroid deficiency, there are a number of conditions of hypothyroidism of a less severe type. But it must be admitted that the diagnosis of hypothyroidism in "borderland cases" is at present very uncertain. Kocher states that many cases which have been treated for anemia, chlorosis, scrofula, nervousness and disturbances of menstruation seem to him clearly to be cases of thyroid deficiency. He also calls attention to the cases in which

Administered to cases of myxedema of cachexia thyreopriva, the myxedematous condition largely disappears There is a marked increase

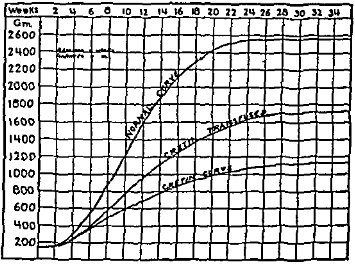

FIG 4A —GROWTH CURVES OF FOUR NORMAL AND THREE ABSOLUTE CRETIN RABBITS SAME LITTER (Basinger)

in metabolism The excretion of nitrogen in the urine may be increased 100 to 200 per cent This increase results largely from the increased

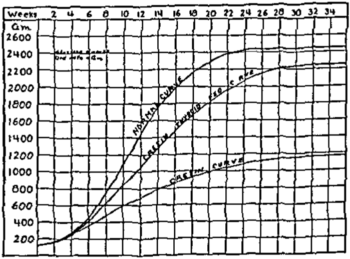

FIG 4B —GROWTH CURVES OF FOUR NORMAL CONTROL RABBITS FIVE ABSOLUTE CRETINS AND EIGHT ABSOLUTE CRETINS FED STANDARD U S P THYROID EXTRACT (Basinger)

intake due to improved appetite, but there is usually a true loss of nitrogen There are *no striking changes* in the partition of the nitrogen in

the urine The consumption of oxygen may be increased 70 per cent The temperature rises, the pulse rate is increased, there is usually a striking loss of weight due to the disappearance of the myxedematous infiltration and loss of fat The entire metabolism is brought back to the normal level or raised slightly above the normal The skin approaches the normal, sweating which is usually entirely absent in myxedema, becomes possible The hair grows again menstruation reappears the bowels become regular the mental condition is much improved These changes begin in three to four weeks with the usual doses of thyroid

The first myxedematous patient treated with thyroid extract by Dr Murray beginning 1891, died in 1920 During these twenty nine years

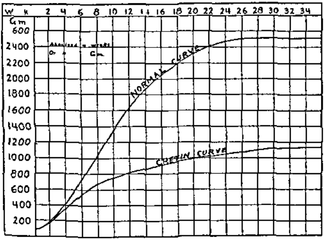

FIG 4C—GROWTH CURVES OF FOUR NORMAL CONTROL RABBITS TWO ABSOLUTE CRETINS AND SIX ABSOLUTE CRETINS TRANSFUSED REPEATEDLY WITH HYPERTHYROID BLOOD SERUM (Basinger)

the patient enjoyed ordinary good health and the myxedema was kept under control by continuous thyroid feeding

The marked changes in the skin in cases of myxedema produced by the administration of thyroid have led to the extensive trial of this substance in other abnormal conditions of the skin

Thyroid Feeding in Conditions of Mild Hypothyroidism—In addition to the above conditions in which there is obviously severe thyroid deficiency there are a number of conditions of hypothyroidism of a less severe type But it must be admitted that the diagnosis of hypothyroidism in "borderland cases" is at present very uncertain Kocher states that many cases which have been treated for anemia chlorosis scrofula nervousness and disturbances of menstruation seem to him clearly to be cases of thyroid deficiency He also calls attention to the cases in which

children show retarded growth with no apparent cause The favorable results following the administration of thyroid make the diagnosis of the condition clear Many of the cases of mild thyroid deficiency show, according to Kocher, very definite symptoms, among the most marked of which is a feeling of inhibition preventing the subjects from accomplishing that which they desire They are incapable of continued effort, such as reading, writing, and even speaking, they become shy and avoid society They are indifferent to food, and neglect going to stool Kocher states that improvement follows the administration of thyroid in such cases

Kocher mentions many other symptoms due, as the effect of thyroid treatment appears to show, to slight thyroid deficiency Among these are fatigue from slight exertion, although muscular development is good, slight swelling of the eyelids, lips and cheeks, tendency to obesity, and the appearance of local accumulations of fat, swelling of the joints, so that patients frequently state that they suffer from gout or rheumatism, paresthesia, especially feelings of stiffness *Sometimes the skin* has a yellowish tinge, suggesting chlorosis. Pigmentation of the skin is frequent, resembling that seen in pregnancy, the pigmentation in the latter condition may be due to relative thyroid insufficiency The pigmentation often disappears under the influence of thyroid Kocher raises the question whether the effect of the thyroid in such cases may not be due to an effect upon the suprarenals or other organs of internal secretion

Further changes in the skin and its appendages, upon which Kocher lays much emphasis, are dryness and coldness, with little tendency to sweating, the dryness of the hair and its tendency to fall out, the tendency of the nails to crack and of the teeth to caries

Kocher warns against ascribing more severe skin diseases to a condition of hypothyroidism, although he states that eczema, ichthyosis, etc, are especially prone to occur where the nutrition of the skin is deficient as a result of hypothyroidism

Individuals with these mild degrees of hypothyroidism are sensitive to the cold The coldness of the skin is due to sluggish circulation, which is also evident from the weak pulse

Kocher states that marked improvement occurs in such cases as the above within a week or ten days (sometimes even in twenty four hours) after beginning the administration of thyroid Similarly beneficial results are stated to occur in the aged, when symptoms of thyroid hypofunction result from the gradual deterioration of the gland, and in pregnancy, when the thyroid may be unable to meet the increased demands made upon it

Various chronic diseases and intoxications (tuberculosis, alcoholism, and sometimes syphilis) may injure the thyroid, so that a mild degree of hypothyroidism results, here again thyroid medication may be of benefit

Stoeltzner states that rudimentary forms of infantile myxedema characterized by cessation of growth, excessive fatness, etc are not uncommon, they sometimes follow infectious diseases or traumatism In such cases, thyroid causes some improvement Simpson reports favorable results in many cases of infantile wasting

Effects of Thyroid Administration in Normal Individuals—Similar effects upon metabolism, but less marked and less constantly obtained are produced when thyroid is administered to normal individuals and to normal animals The effect in normal animals is largely a question of quantities of thyroid given, and of the species man being the most susceptible And there are great individual variations in the susceptibility to thyroid among apparently normal persons The absorption of oxygen and the excretion of carbon dioxid may be increased 10 to 20 per cent although in some cases there is no increase The excretion of urinary nitrogen may be increased 20 to 50 per cent usually it is less, much depending on the character of the diet The change in nitrogen metabolism usually occurs first that in total metabolism occurs later (in the course of two to three weeks) Increased destruction of protein cannot always be prevented by the administration of non nitrogenous food Hewitt reports, however, that fresh thyroid fed to adult rats in doses of 0 25 gram or less per day, leads to increased food consumption and body weight, while larger doses have the opposite effect Large doses of thyroid or thyroxin decrease the rate of growth in young rats and rabbits, cause hypertrophy of the heart liver kidneys and adrenals (Hoskins Cameron and Carmichael) Feeding thyroid to young rabbits stimulates the bone marrow (Lim) Thyroid feeding in rats is said to produce tetany (Cameron and Carmichael), and a decreased nitrogen and gaseous metabolism (Kojima)

The excretion of phosphorus and of sulphur is said to be increased There is, in man, usually a distinct increase in nervous excitability with attendant circulatory and other disturbances Gudernatsch found that feeding thyroid to frog tadpoles greatly accelerates the metamorphosis while growth is actually retarded This does not appear absolutely specific for the thyroid substance, as Morse and Swingle obtained the same result with iodized blood albumin and Abderhalden with thyroid protein hydrolyzed down to the amino-acid stage According to Lim thyroid feeding stimulates general cell mitosis in the tadpole

No other organ has such marked effects upon metabolism and many attempts have been made to utilize these effects therapeutically

Indications for Use of Thyroid—The indications for the use of thyroid are clear in those cases in which there is a deficiency in the normal secretion in other cases however its administration must be largely determined empirically and it must first be shown that the type of increased metabolism induced by thyroid feeding is really beneficial in

cases where there is not depression of metabolism due to thyroid deficiency. The mode of action of thyroid upon metabolism is obscure. *Some believe* that it stimulates the cells directly to increased activity, whereas others think that the effect is primarily upon various parts of the nervous system, the stimulation of which causes increased activity which results in increased metabolism. In support of the latter view, Anderson and Bergmann state that there is no increase in the carbon dioxid output when thyroid is administered to a person kept in a perfect quiet.

That excessive amounts of thyroid do increase nervous irritability is generally accepted on the basis of observations in Graves' disease and the results of administering large doses of thyroid. Magnus-Levy believes *that there are great individual differences, but that in some cases* there is an increased metabolism of the resting cells. It is evident that the solution of this problem has important bearings upon the use of thyroid to influence metabolism, if the thyroid increases metabolism only indirectly by causing through stimulation of the nervous system, increased activity it could, for example, scarcely be considered a good treatment of obesity, at least in those forms in which thyroid deficiency is not a causal factor.

Excessive doses of thyroid have marked effects upon the circulatory and nervous systems, but these are of interest chiefly in connection with *the toxic action of the drug, they do not suggest any therapeutic use for* it. Eppinger, Falta, and Rudinger attribute many of these effects to increased irritability of the sympathetic nervous system. Zondek and Frankfurter state that thyroid extract and iodothyrin cause bronchoconstriction and dilatation of the lung capillaries.

Thyroid Organotherapy in Other Conditions

Thyroid has been given in many conditions that have not yet been definitely shown to be caused by thyroid deficiency. In some of these thyroid deficiency is merely suspected, in others thyroid is apparently used because the symptoms resemble some of those occurring in hypothyroidism. Among these conditions are various disturbances of the skin, especially the dry scaly varieties. Thus it has been recommended in eczema, especially that of early childhood and of old age, it has been used in psoriasis, chronic urticaria, pemphigus, ichthyosis, and scleroderma. In the latter condition the thyroid has sometimes been found atrophied (*Wells*).

Thyroid treatment has been tried in the toxemias of pregnancy on the theory that the intoxication is due to thyroid deficiency. This theory is highly improbable, as the syndrome of hypothyroidism does not at all resemble pregnancy toxemias.

It has been used in various disturbances of the joints, such as arthritis

deformans, irregular gout, chronic rheumatism and indefinite rheumatoid pains Among recent writers Levi and Rothschild have especially emphasized its value in certain forms of rheumatism of children in these the thyroid is frequently enlarged (Clemens) It has also been used in cases of migraine and neuralgia especially in those associated with menstruation Thyroid has found extensive use in various disorders of menstruation Experimental and clinical work has shown that the thyroid is necessary for the proper development of the gonads the genital organs and for menstruation Further relations between the thyroid *and the female sexual organs are suggested by the more frequent occurrence* of myxedema in women after the climacteric—especially in those who have borne children—the more frequent occurrence of exophthalmic goiter in women, and by the enlargement of the thyroid during menstruation and pregnancy It has been recommended in amenorrhea when other causes cannot be detected and especially if there is a tendency to obesity or myxedema Thyroid in large doses has been used in eclampsia

The influence of the administration of thyroid upon the defective growth of bone in cretinism suggested its use in delayed union of fractures some writers have reported favorable results Bircher reports that the administration of thyroid to young animals delayed bone growth this was probably due to excessive doses He does not believe that the effect *on bone* growth in cretinism is specific Thompson and Swarts contrary to some, did not find that removal of the thyroid delayed the healing of fractures It has been said to have good results in rickets Glosse proposes the theory that arthritis with accompanying disturbances of protein metabolism is due to lack of thyroid secretion which he considers, under normal conditions to act as a deamidizing agent

Good results have been reported from the use of thyroid in hemophilia It is said that the preliminary administration of the drug renders necessary operations (extraction of a tooth for example) safer Such results must be doubted, for the coagulation of blood is said to be distinctly delayed in Graves disease and experimental hyperthyroidism (and to be accelerated in conditions of hypothyroidism) Frazier and Peet have recently reported the cure of a case of internal *hydrocephalus by thyroid* administration They were led to use this treatment by their laboratory findings that thyroid extract decreases the rate of formation of cerebrospinal fluid This observation is probably erroneous (Becht and Mattill)

The marked mental changes produced by the administration of thyroid in myxedema and cretinism have led to the use of thyroid in various other types of insanity, mental disturbances epilepsy etc The results in certain cases of beginning melancholic insanities are stated to have been good It is interesting to note in this connection that a very large percentage of patients with mental diseases has abnormal thyroids and that Grafe has found in certain mental diseases a true retardation of metabo-

lism (heat production 30 per cent below normal, for example) which is suggestive of a condition of hypothyroidism Ross administered thyroid to four dementia præcox patients and found an increased excretion of total nitrogen and of creatinin—this in evidence of hypothyroidism as a factor in this malady

Space does not permit, and in many cases the clinical reports are too incomplete, to evaluate the alleged favorable results of this purely empirical thyroid organotherapy, but the following comments seem warranted (1) If there is in the patient sufficient hypothyroidism to induce amenorrhea, mental disorders, skin lesions, defective bone metabolism, lowered resistance to infection, etc, there must be other indubitable signs of thyroid deficiency, such as lowered basal metabolism (2) Unless these conditions are due to hypothyroidism, administration of thyroid to these patients will, on the theory of Mobius, *induce a state of hyperthyroidism* and there is no evidence that this condition has a favorable influence on any malady (3) There is no evidence that the augmented metabolism induced by thyroid administration is beneficial in any other condition than cretinism and myxedema Moreover, a general increase in body metabolism can be induced by dietetic and hygienic measures, cold baths, exercises, etc (4) *When the failures are balanced against the favorable* results in all cases of empirical thyroid organotherapy, there is little basis left for the belief that the thyroid treatment is really responsible for the latter

Methods of Administering Thyroid

Transplantation—The earliest attempts to combat deficiency were by the transplantation of normal thyroid This method has succeeded when the thyroid is transplanted to another region of the same individual, it has been less successful when the gland is transplanted from one animal to another of the same species It is, therefore, of experimental but of little or no practical clinical importance It has been recommended in cases in which thyroid feeding does not produce notable improvement, as is usually the case in endemic cretinism (cretinic degeneration) Kocher states that one advantage of transplantation is that the body can regulate the amount of secretion according to its needs, but that is not true of a *thyroid graft from another individual, even under the most favorable* conditions (Manley and Marine)

Subcutaneous Injections—Murray (1891) introduced the method of treating myxedema by the subcutaneous injection of glycerin extracts of thyroid, the extracts were obtained from sheep and calves, and were preserved with phenol They frequently caused severe local reactions This method has no advantage over feeding the thyroid by mouth, but many disadvantages It should never be resorted to Thyroxin may be given

intravenously or hypodermically but this therapy has no advantage over thyroid extract feeding, and is at present very expensive for the patient

Administration by Mouth—A very important advance in thyroid medication was made in 1892 when Fox Mackenzie and Howitz almost simultaneously announced that favorable results could be obtained in myxedema, by the administration *per os* of the fresh or cooked thyroid The use of cooked and fresh glands was soon practically replaced by the use of the dried glands and of various extracts Some of these have received recognition in various pharmacopeias

Official and Other Preparations of Thyroid

Pharmacopeial Preparations—Desiccated thyroid gland is recognized in the United States Pharmacopeia (VIII, 1905) under the name Glandulæ Thyroideæ Siccæ It is directed to be obtained from the sheep and to be freed of fat, and powdered one part represents approximately five parts of the fresh glands Tests are included to insure the presence of iodin in organic combination and the absence of inorganic iodin The average dose is given as 0 25 gram, or four grains

Tablets—At present thyroid is administered at least in this country chiefly as the dried powder which is usually prescribed in the form of tablets Such tablets are very convenient and satisfactory if they are well chewed but their use has led to the utmost confusion as to dosage Many physicians both here and abroad speak of prescribing so many tablets without, as a rule specifying either the size of the tablet or the maker, others speak of prescribing two or five-grain tablets' without specifying whether the weight refers to the total weight of the tablet (that is the thyroid plus the excipient) or to the thyroid alone, and in the latter case, as to whether the weight refers to the fresh or dried gland Others specify some manufacturers tablets' without further particulars How inexcusably inexact such procedures are is evident from such facts as the following Many manufacturers prepare several tablets of different sizes one firm for example lists one-half one and one half, two and one-half and five-grain, and one-tenth, and three-tenths grain tablets' which of these tablets the patient received when the physician states that he administered this firm s tablets it is usually impossible to determine

The confusion as to dosage is still further increased by the fact that different firms use different methods of expressing the amount of thyroid in their tablets Thus one firm s five-grain tablet contains two grains of desiccated thyroid another firm s five-grain tablet means that each tablet contains the equivalent of five grains of the fresh gland One firm s two-grain tablet means that each tablet is equivalent to ten grains of the fresh thyroid another firm states that one gram of their

dry thyroid represents eight grains of the fresh gland There can be little doubt that, when some physicians write of prescribing a five-grain tablet of dry thyroid, they really prescribe a tablet containing the equivalent of five grains of fresh thyroid, or one fifth of what the reader may be led to suppose

Since some "commercial" tablets contain twenty times as much thyroid as other tablets and since some preparations of thyroid are four times as active as others, there is a *possibility* of one "tablet" being equal, physiologically, to eighty other "tablets" [3]

Extracts and Other Preparations—In addition to the above, there are a number of extracts and other preparations of the thyroid on the market The term extract is frequently applied to the dried powder, a practice often leading to confusion

Thyroidin Merck—Reference to this preparation is frequently made in the literature It is dried thyroid 4 grain of which is equivalent to one fresh sheep thyroid of medium size one part represents about six parts of the fresh gland

Thyroidin Notkin—This is a preparation of the proteins of the thyroid stated to be especially useful for hypodermatic injection The dose *per os* is one sixth of a grain hypodermatically, 15 minims of a 5 per cent solution

Thyroxin (Kendall)—This is manufactured under Dr Kendall's direction by Squibb It is a crystalline substance containing 65 per cent iodin The dose is one or more milligrams depending on the degree of hypofunction of the patient's thyroid Squibb also puts on the market a form of thyroxin not completely purified

Untoward Effects and Contra indications—Untoward effects not infrequently follow the medicinal use of thyroid There are however, great individual differences in susceptibility Children are stated to be less sensitive than adults, *patients with myxedema as well as with toxic goiter are usually hypersensitive This applies also to experimental cretins*

Among the milder symptoms reported from overdoses, the long-continued use of smaller doses, or in especially sensitive individuals, are *flushing with increased sweating, fullness of the head with palpitation of* the heart, tachycardia and angina c pain in the heart, dyspnea faintness, dizziness, loss of appetite, loss of body weight, etc Such symptoms have followed the taking of two grains of the dry powder Other symptoms are nausea vomiting and severe diarrhea Toulis reported a case of profuse fatal diarrhea following the first dose of one-fourth of a lobe of thyroid in twenty four hours Glycosuria often occurs Marked

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[3] The above remark applies to the tablets on the American market. Equally great confusion prevails in regard to other tablets on foreign markets thus *in one case* a 1-gram tablet contains one fourth of a medium sized thyroid of a sheep

nervous disturbances may occur In addition to the palpitation etc, there may be great restlessness and sleeplessness irritability tremors, pains in the back and extremities and even delirium The temperature is sometimes elevated Urticaria and other disturbances of the skin may occur Great emaciation long continued debility and anemia have been reported, the urine may be diminished although as a rule thyroid has a diuretic action As a rule these untoward effects subside within a few days after stopping the thyroid treatment but Krecke reports that he has seen emaciation tachycardia and excitement continuing for a year after the administration of thyroid to patients with Graves disease This was in all probability not due to the thyroid therapy

A large number of accidents some of them fatal have occurred from the use of thyroid in obesity It is especially dangerous to obese patients with a tendency to cardiac or aortic disease It is also contra indicated in obese patients with a tendency to diabetes

Summary

1 Thyroid organotherapy is definitely established in all conditions of hypothyroidism that is in all degrees of cretinism and myxedema *The administration of the entire gland substance (dried) by mouth in doses that must be determined for each individual patient is the best method of procedure* This therapy must ordinarily be continued indefinitely We should insist on chemical and physiological standardization of the thyroid products

2 Because of the present uncertainty as to the cause and significance of the thyroid hyperplasia in toxic goiter and the not infrequent occurrence of toxic goiter and myxedema in the same patient at the same time thyroid administration may be tried experimentally in these conditions, especially in the very early and in the later stages But Howard believes this use of thyroid extract should be discouraged

3 If we assume, with Mobius that an excess of thyroid secretion in the blood produces the untoward symptoms of toxic goiter it follows that an increase of thyroid secretion above the normal is injurious Hence on this generally accepted theory it is evident that thyroid administration is contra indicated in all conditions *not* due to thyroid deficiency, for by giving thyroid in such cases we probably increase its concentration above the normal in the body fluids and the tissues. The results obtained by thyroid organotherapy in various diseases other than hypothyroidism do not appear to justify further clinical empiricism in that direction until well-controlled laboratory tests have established new lines of attack

4 The various theories ascribing to the thyroids specific inhibitory or stimulating functions on other endocrine organs other than through the general body metabolism, have so little basis in fact that there is no

justification for thyroid administration in cases of supposed hyperactivity or hypo-activity of such organs, or in supposed general disturbance of internal secretion equilibrium

THE PARATHYROIDS

Physiology—The parathyroids, like the thyroid gland, develop from the epithelium of the embryonic gill arches In man and most mammals the parathyroids are either imbedded in the thyroid gland or lie close to the thyroid capsule There are usually two pairs of parathyroid glands in man and mammals in general, but accessory parathyroids are frequently present in the thymus, and associated with accessory nodules of thyroid tissue both in the neck and the chest The glands were discovered by Sandstrom in 1880, but their specific role was not recognized by physiologists and clinicians until a much later date Because of the situation of the parathyroids in or on the thyroid gland, complete thyroidectomy involves, in most mammals, also complete parathyroidectomy, and the characteristic syndrome developing as a result of parathyroid extirpation as for many years erroneously ascribed to deficiency of the thyroids

The striking thing is the relatively small amount of total parathyroid tissue in animals, and the serious effect that develops promptly on the extirpation of the glands, at least in many species Histologically the *parathyroids are made up of columns of epithelial cells, without the acini* or colloid so characteristic of the thyroid gland Vincent and his pupils have reported that on extirpation of the thyroids the parathyroids develop into typical thyroid structure Vincent has adduced other evidence in support of his theory that the parathyroid glands represent an embryonic state of the thyroid But Vincent's experimental results have not been substantiated by other investigators It is certain that in the rabbit complete thyroidectomy does not cause the parathyroids to assume the structure and function of the thyroid (Basinger) The functional independence of the thyroid and the parathyroids is further shown by the absence of iodin in the parathyroid gland The earlier workers who reported iodin in the parathyroids were not careful to exclude traces of thyroid tissue This is practically impossible if one uses the parathyroids that are embedded in the body of the thyroid gland

While it is generally assumed that the parathyroids produce an internal secretion, this theory rests on a very slight foundation of facts It is a fact that complete extirpation of the glands leads quickly to the development of grave or fatal symptoms but we do not know how the living parathyroids prevent the toxemia of tetany

Extirpation of the Parathyroid—Practically all that is known of the functions of the parathyroids has been learned from the extirpation of these glands in animals and man The typical symptoms in animals are as follows There is a latent period of several (twelve to forty-eight) hours in which the only symptoms may be a loss of appetite some increased thirst, and a condition of hyperirritability of peripheral nerves Then appear general unrest and fibrillary contractions of various muscles especially of the tongue and jaws these become more frequent and are accompanied by a stiffness of the extremities and clonic contractions of groups of muscles The clonic contractions then extend to all the muscles leading to the typical tetanic attacks which are accompanied by salivation and increased cardiac and respiratory activity and in most animals a rise in temperature These attacks are succeeded by a condition of prostration during which the dyspneic respiration gradually returns to normal The animals may apparently completely recover but within a few hours or a day or two, new attacks develop and death occurs In dogs the duration of life after complete removal of the parathyroids rarely exceeds ten to fourteen days

If only two or three parathyroids are removed there may develop a condition of latent tetany in this case there are often no symptoms except under special conditions Among the influences provoking attacks of tetany in such animals are the occurrence of rut pregnancy lactation violent nervous and muscular exertion, constipation high protein diet The administration of various poisons (phosphorus, amines etc) may also provoke an attack

The rate of development and the final degree of the increased excitability of the motor neurons following parathyroidectomy in the dog are not appreciably influenced by ablation of the cerebral motor cortex spinal transection, or section of the dorsal nerve roots The increased excitability is therefore probably due primarily to some direct chemical action on the motor neurons

The course of the parathyroid tetany is not appreciably influenced by ablation of the motor cerebral cortex or by rendering a limb atonic through section of its afferent nerves

As the epileptic spasms or tetanic attacks following removal of the parathyroid glands do not develop posterior to the spinal transection it would seem that the actual tetany depends not only on the local increase of motor excitability in the spinal cords but also upon nervous connections with some region of the encephalon below the cerebral cortex (Mustard)

Wilcox found that removal of one to two or three of the parathyroids in dogs may induce more or less permanent hyperexcitability of the nerves but no tremors or tetany even during pregnancy or lactation But it is significant that the nervous hyperexcitability becomes more

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The hunger contractions of the empty stomach in parathyroidectomized dogs are depressed in direct proportion to the severity of the tetany In extreme tetany the empty stomach is atonic and dilated This is probably a factor in the characteristic anorexia of tetany animals

The condition of the digestive tract in experimental parathyroid tetany is of great interest in view of the various types of tetany of gastrointestinal origin in man While it has been known for a long time that feeding meat to parathyroidectomized animals hastens and intensifies the tetany symptoms, and that starvation retards and diminishes the tetany symptoms, it is nevertheless probable that the gastrointestinal symptoms of parathyroid tetany in animals are mainly the effects of the tetany toxemia and not the primary cause of the tetany syndrome

Parathyroid Tetany and the Liver — The injurious effects of protein food and the amines etc various changes in the blood and in the urine glucosuria acidosis increase of ammonia and amino acids in the urine reported by a number of observers in tetany animals have naturally directed attention to the liver Carlson and Jacobson called attention to the marked similarity of parathyroid tetany the tetany of ammonia intoxication and the nervous hyperexcitability produced by meat feeding in dogs with the blood shunted past the liver into the general circulation by the Eck fistula There is some histological evidence of liver degeneration in animals dying in tetany and in the clinical tetany of pregnancy (eclampsia) there appear also to be instances of liver involvement But extensive investigations on tetany dogs have failed to disclose any primary liver depression of importance except a diminished secretion of bile and this is probably due to the condition of the digestive tract rather than to the absence of specific parathyroid secretion But Dragstedt has recently shown that parathyroidectomized dogs in which the appearance of tetany is prevented by suitable diet phosphorus or guanidin administration in quantities having little or no effect in normal animals causes violent tetany

During parathyroid tetany there is no change in the sugar tolerance (Stoland Miura) the excretion of ammonia and amino acids in the urine is normal or less than normal in early tetany (Wilson Stearns and Janney) the blood fibrinogen is normal or greater than normal The formation of fibrinogen is one of the functions of the liver hence the use of the blood fibrinogen is a test of liver function But inasmuch as the secretion of bile is decreased a functional liver test depending on excretion of pigments in the bile would probably disclose erroneously a liver depression in tetany animals Of course it is obvious that when the tetany condition has rendered the animal moribund the liver will be depressed along with the entire organism This is of no significance

marked during pregnancy, and especially during lactation When all the parathyroid tissue is removed in the dogs the hyperexcitability of the peripheral nerves is in evidence one to three days before the appearance of tremors and tetany

In some cases of parathyroidectomy, cachexia and depression appear at the very onset without any evident period of nervous hyperexcitability This is particularly frequent in cats The cachexia and depression is usually accompanied by subnormal temperature Practically all animals that survive the violent attacks of tetany and pyrexia die in cachexia and depression

Extirpation of the parathyroid causes, on the whole, a more violent and rapidly fatal tetany in the carnivora than in herbivora, and in the latter group the adult animals are frequently less affected by loss of the parathyroids than the young animals

Parathyroid Tetany and the Digestive Tract —Parathyroid tetany in dogs is accompanied by gastro-intestinal disorders, anorexia, vomiting, diarrhea (usually), pain in the abdominal region, and in the majority of cases hyperemia, hemorrhages and ulcers of pyloric and duodenal mucosa The hyperexcitability of the peripheral nerves in dogs in parathyroid tetany is usually, but not always, shown by stimulation of the phrenic nerves by the action current of the heart

Falta and Kahn describe cases of tetanic contraction of the stomach in human tetany There are no spasms contractures or other evidences of hyperexcitability or tetany of the neuromuscular mechanisms of the digestive tract in parathyroid tetany in cats and dogs Even in very severe tetany the movements of the stomach and intestines may be normal, the deviation from normal is in the direction of depression or paralysis The gastric and pancreatic digestion in tetany may be normal, but it is usually retarded The retardation may amount to practical failure of digestion In very exceptional instances there may be acceleration of the gastric motility (cats) The retarded digestion is not due to the absence of appetite secretion or to splanchnic inhibition, it is probably due either to direct action of substances in the blood on the digestive glands (secondary effects), or to altered activity as a direct effect of the absence of the parathyroid secretion In the case of other sympathetic and automatic mechanisms (cervical sympathetic, pilomotors, sweat nerves, the uterus, the bladder, the sphincters), the deviation from normal activity in parathyroid tetany in cats and dogs seems also to be in the direction of depression

In cats and dogs Keeton found a diminished secretion of gastric juice during parathyroid tetany, and the juice contains less than the normal amount of pepsin and hydrochloric acid The impairment of the gastric secretion is on the whole, directly proportional to the severity of the tetany Stoland found that the quantity of the pan

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the urine of tetany dogs. Injection of these substances into animals induces symptoms similar to parathyroid tetany. But there is no evidence that there is sufficient concentration of guanidin in the blood to induce the tetany in parathyroidectomized dogs. Using biological tests several observers have reported an increased toxicity of the urine of tetany animals.

Wilson, Stearns and Janney find that after parathyroidectomy there is a primary alkalosis, or greatly increased alkalinity of the blood, and that acidosis is a secondary effect of the severe tetany owing to the formation of acids as a result of the muscular contraction. These observers advance the theory that the alkalosis is the primary factor in the tetany and support this view by the fact that giving of alkalis increases the tetany, while administration of acids decreases the tetany. The reader will recall that MacCallum found similar support for his theory of primary calcium deficiency in the fact that calcium injections decrease the tetany symptoms temporarily. Acids as well as calcium salts depress the nervous tissues, but this drug action does not prove the primary relation of alkali excess or calcium deficiency to the genesis of parathyroid tetany.

Several investigators (Grant and Goodman, etc.) have recently reported the production of a temporary tetany in man and animals by excessive lung ventilation (forced breathing), thus reducing the carbon dioxid of the blood and presumably increasing the alkalis. But these findings do not explain parathyroid tetany. According to Greenwald the tetany following forced respiration is due to the excess sodium ions in the blood. Uhlenhuth has reported tetany toxins in the thymus (feeding thymus to tadpoles).

Temporary Control of Experimental Parathyroid Tetany.—Some of the earliest investigators of the physiology of the parathyroids (Lusena, Vassale, Generali, Moussu, MacCallum) reported that the tetany could be checked by the injection (subcutaneous, intraperitoneal or intravenous) of emulsions of the parathyroids; favorable results were also reported from the feeding of the gland. Berkeley and Beebe report that the active part of the gland is the nucleoprotein fraction; this was said to be efficient when given by the mouth but much more so when given subcutaneously.

The treatment of parathyroid tetany by the administration of the parathyroid glands differs in important particulars from that of myxedema by the administration of thyroid. The effect of thyroid is strictly specific, no other gland substance will relieve the symptoms. It has been found, on the other hand, that parathyroid tetany can be temporarily checked, at least in the early stages, by the administration of salts of calcium, magnesium, strontium and barium, by the injection of large amounts of sodium chlorid solution, by the injection of acids, by injection of extracts of the thyroid, the thymus, the pancreas, the testes, and the hypophysis, by the injection of proteoses or peptones, by the injection

The question of importance is whether there is any evidence of liver depression that can account for the genesis of the tetany itself. Such liver changes have not yet been demonstrated.

The Blood in Parathyroid Tetany.—The literature on this most important phase of parathyroid physiology and pathology is conflicting. MacCallum and Voegtlin reported a marked acidosis, with a decrease of the calcium salts of the tissues and the blood and an increased excretion of calcium in the urine. None of these results has been confirmed (Cooke). But Marriott and Howland report a decreased calcium content in the blood of spasmophilic children. Berkheim, Stewart and Hawk report a case of probably complete parathyroidectomy in a man, with slight retention of calcium salts. In later experiments MacCallum reported that transfusion of the blood of tetany dogs through the leg of a normal dog raised the excitability of the motor nerves of the transfused leg of a tetany dog, while transfusion of normal blood through the leg of a tetany dog reduced the excitability of the nerves of the tetany leg. It does not appear that Dr. MacCallum controlled the *temperature factor* of the transfused blood. Fever blood will, of course, raise the excitability of the nerves, by the temperature factor alone. Yoshimoto reports that the blood of dogs in tetany, as well as solutions of guanidin, increases the irritability of the sciatic nerve of the frog.

In connection with the theory of calcium deficiency on the course of tetany, it is interesting to note that Thompson, Leighton and Swartz, and Morel have reported that traumatism of bone prevents tetany from removal of the parathyroids; it does not, however, prevent the development of cachexia.

Peterson, Jobling and Eggstein report a diminution of the serum lipase, a gradual increase in the non-coagulable nitrogen and proteoses of the blood and an increase in the aminonitrogen at the height of the tetany. Cooke and Greenwald report an increase in the undetermined urine nitrogen. According to Greenwald there is a marked retention of phosphorus after parathyroidectomy, and this is accompanied by retention of sodium and potassium. But in the quantities present the sodium or potassium phosphates are probably not sufficiently toxic to be the agent of the tetany.

Greenwald also showed that xanthin and inosinic acid are not the toxic agents, for there is not enough of either of these substances in the blood or tissue of tetany animals to cause symptoms, although intravenous injections of large amounts of xanthin cause convulsions. The significance of the phosphorus retention in parathyroid tetany is as yet unexplained, but the work of Erdheim and others indicates that chronic parathyroid deficiency leads to impairment of bone growth.

Koch and Paton, Findlay and Burns report that there is an increase in the excretion of methyl cyanids, and trimethylamin, or guanidin in

Dragstedt has shown that parathyroidectomy in dogs on a diet of milk lactose and bread or dextrin does not lead to tetany or death and if this diet is kept up from four to six weeks the ordinary meat diet (in moderation) may be restored without inducing tetany The above diet changes the intestinal flora in dogs from the normal putrefactive to an aciduric type This diet is not invariably successful in preventing tetany and maintaining life after parathyroidectomy in pregnant bitches This indicates that the fetus (and possibly the placenta) is a source of tetany toxins These clear-cut experiments on non pregnant dogs seem to show that

1 The tetany is due to exogenous toxins and these toxins are developed by the intestinal proteolytic flora acting mainly on the food protein (meat)

2 The parathyroids in dogs are not necessary for life After the initial dietary control of the acute symptoms the dog seems quite normal, even on a meat diet. This may be due to an increased tolerance to the tetany toxins or an increased destruction of these toxins by other organs in the body

3 The dogs are not normal They are in the condition of latent tetany or epilepsy so that constipation excessive ingestion of meat, rut, pregnancy, poisons, or excitement induce tetany attacks of varying severity

Luckhardt has shown that parathyroidectomized dogs (pregnant as well as non pregnant) on a high meat diet can be kept free from tetany (1) by a daily feeding of large quantities of calcium lactate (about 1 5 gr per kilo body weight) for from four to five weeks after the operation and (2) by maintaining a brisk diuresis for a corresponding period by means of intravenous injections of large quantities of Ringer's solution or salt solution After four or five weeks both the calcium and the diuresis therapy can be dispensed with the animals live indefinitely and show no tetany, except under the same conditions as stated in Dragstedt's experiments *All of Luckhardt's parathyroidectomized dogs that have lived for a year or more have developed cataract*

Luckhardt's diuresis experiments can be most readily explained on the basis of rapid elimination of the tetany toxins by the kidneys The life-saving action of calcium lactate when given by mouth is less readily understood Calcium lactate intravenously will not save a parathyroidectomized dog from death in fact *given in this way the salt produces nephritis* The huge doses of the salt necessary *per os* is a further indication that the mechanism is not that of making up a calcium deficiency in the tissues The calcium may act in the gut by modifying the action of the intestinal bacteria, or fixing bacterial toxins

of hypertonic sugar solutions, by the administration of amyl nitrate, etc In dogs the early attacks of parathyroid tetany can usually be decreased or prevented by giving the animal a cold bath, reducing the pyrexia Transfusion of normal blood into parathyroid tetany dogs decreases the tetany but little and does not lengthen the life of the animal

Administration by Mouth—Giving parathyroids by mouth appears to be entirely useless in the hands of later investigators (MacCallum and Voegtlin Marine) Marine gave as many as one hundred fresh parathyroids per day to dogs with complete tetany without amelioration of the symptoms or prolongation of life but transplantation of even a single parathyroid from another species controlled the tetany for a few days, or until the gland was completely absorbed

All these measures have so far proved to be only temporary palliatives Their action is complicated by the spontaneous periodicity of the symptoms in the early stages of the disease and by the complete and spontaneous recovery in some individuals The efficiency of these measures varies indirectly with the stage of the cachexia and the severity of the excitation symptoms The action of all these therapeutic measures can probably be accounted for by *decreased excitability* of the nervous tissues The excitability is decreased *directly by the drug action of the calcium and the* strontium salts and by hypertonicity indirectly by substances or measures that cause partial anemia of the brain through vasodilatation (tissue extracts albumoses amyl nitrite stimulation of the depressor nerves) None of these measures has therefore any *specific* significance as regards the cause and nature of parathyroid tetany

In most of the experiments the administration of the above substances has relieved the symptoms of tetany only the animals dying later in cachexia *The cases of complete recovery are probably due to hypertrophy* of accessory glands or to gradually acquired tolerance to the tetany toxins Thus valuable as the administration of the gland or injections of salts of calcium may be in checking the symptoms of tetany and in prolonging life, it is open to question whether it is possible to restore normal conditions in complete parathyroidectomy, except by successful implantation of a living gland

Transplantation of Glands—For the complete relief of parathyroid insufficiency *transplantation of the glands* is the only effective measure, but the results have been disappointing (Halsted Leischner and Kohler, Landois Marine and others) Halsted concludes that transplantation succeeds only when a parathyroid deficiency has been previously induced and that parathyroid tissue transplanted in excess of what is urgently required by *the organism does not live*

Permanent Control of Parathyroid Tetany in Dogs—It has been found that parathyroid tetany in dogs can be permanently controlled by diet, diuresis, and feeding of calcium lactate

Dragstedt has shown that parathyroidectomy in dogs on a diet of milk, lactose and bread or dextrin does not lead to tetany or death and if this diet is kept up from four to six weeks the ordinary meat diet (in moderation) may be restored without inducing tetany. The above diet changes the intestinal flora in dogs from the normal putrefactive to an aciduric type. This diet is not invariably successful in preventing tetany and maintaining life after parathyroidectomy in pregnant bitches. This indicates that the fetus (and possibly the placenta) is a source of tetany toxins. These clear-cut experiments on non pregnant dogs seem to show that

1. The tetany is due to exogenous toxin and these toxins are developed by the intestinal proteolytic flora acting mainly on the food proteins (meat).

2. The parathyroids in dogs are not necessary for life. After the initial dietary control of the acute symptoms the dog seems quite normal even on a meat diet. This may be due to an increased tolerance to the tetany toxins or an increased destruction of these toxins by other organs in the body.

3. The dogs are not normal. They are in the condition of latent tetany or epilepsy, so that constipation, excessive ingestion of meat, rut, pregnancy, poisons, or excitement induce tetany attacks of varying severity.

Luckhardt has shown that parathyroidectomized dogs (pregnant as well as non pregnant) on a high meat diet can be kept free from tetany (1) by a daily feeding of large quantities of calcium lactate (about 1 gr. per kilo body weight) for from four to five weeks after the operation and (2) by maintaining a brisk diuresis for a corresponding period by means of intravenous injections of large quantities of Ringer's solution or salt solution. After four or five weeks both the calcium and the diuresis therapy can be dispensed with, the animals live indefinitely and show no tetany except under the same conditions as stated in Dragstedt's experiments. *All of Luckhardt's parathyroidectomized dogs that have lived for a year or more have developed cataract.*

Luckhardt's diuresis experiments can be most readily explained on the basis of rapid elimination of the tetany toxins by the kidneys. The life-saving action of calcium lactate when given by mouth is less readily understood. Calcium lactate intravenously will not save a parathyroidectomized dog from death; in fact, *given in this way the salt produces nephritis*. The huge doses of the salt necessary *per os* is a further indication that the mechanism is not that of making up a calcium deficiency in the tissues. The calcium may act in the gut by modifying the action of the intestinal bacteria or fixing bacterial toxins.

The work of these two investigators has greatly advanced our analysis of parathyroid function and parathyroid tetany It has given us an adequate and practical therapy of this tetany It suggests new lines of therapy of tetany and allied disorders in man. But it does not tell us how the intact and normal parathyroids prevent tetany, whether by direct neutralization of the toxins, or by furnishing a hormone that regulates the permeability of the intestinal mucosa, or stimulates various organs to increased detoxication

Parathyroid Deficiency in Man—The clearest cases of parathyroid insufficiency in man are those in which the glands have been more or less completely removed or injured at operation on the thyroid Cases of this character are not uncommon, especially from interference with the circulation of the glands The symptoms of postoperative tetany in man are very similar to those described in animals If death does not occur in a short time a chronic condition of latent tetany or of subtetanic hypoparathyreosis (Halsted) develops Such a condition may continue for years with chronic nervous hyperexcitability (Erb, Chvostek and Trousseau signs), the patient having attacks of tetany at irregular intervals.

Another form of tetany, in which a condition of parathyroid insufficiency *may* exist is that which occurs in pregnancy or lactation At other times there may be no evidence of tetany This form is strikingly like that observed in parathyroidectomized animals, it has also been observed in women after operation on the thyroid (Frank) Krabbel reports the case of a girl who for seven years had tetany only during menstruation, she was completely relieved by the implantation of parathyroids into the tibia Cases are also reported in which coitus induced tetanic convulsions

Another form of tetany the etiology of which is still obscure, is that of children A number of writers have reported finding extensive hemorrhages into the parathyroid glands in this condition Others, however, state that such hemorrhages are comparatively common in infants, and maintain that they are found as frequently in children who do not show tetany symptoms during life as in those who do (Auerbach) Extensive hemorrhages into the parathyroids have been reported in cases of sudden death, with spasms of children (Grosser and Betke) Haskins and Gerstenberger found no evidence of parathyroid involvement in infantile tetany

Attempts have been made to bring tetany of gastro intestinal origin, toxic tetany, and those forms associated with various nervous diseases, into relation with the parathyroids Parathyroid deficiency has been suspected as a factor in paralysis agitans myotonia congenita myoclonia, chorea, *osteomalacia, rickets, eclampsia, and idiopathic epilepsy*, but nothing conclusive has as yet been demonstrated Greenwald s studies on the blood of paralysis agitans do not support the theory of parathyroid

genesis of this disease According to Cornby some types of idiocy are due to parathyroid deficiency

Spontaneous atrophy or hypertrophy of the parathyroids in man have not been definitely established, but they probably occur especially with age Gjestland reports hyperplasia of the parathyroids in Parkinson s disease Roussy and Clunet report parathyroid hyperplasia in paralysis agitans Bergstrand and others have reported parathyroid hyperplasia in chronic nephritis

Parathyroid Organotherapy —Efforts to control the tetany following the removal of the parathyroids or the effects of interference with their blood supply by the administration of parathyroids have met with no certain success Halsted states that in a patient suffering from subtetanic hypoparathyroidism as the result of two operations upon a large goiter, tetany had for three years been averted and the status parathyreoprivus made endurable by the feeding of parathyroids by hypodermic injections of the nucleoproteins of the parathyroid gland and for almost one year by the administration of calcium lactate At the beginning six dried beefs parathyroids were given every three hours the effect was almost instantaneous and most marvelous The dose was then reduced to one gland three times daily further reductions could not for several weeks be borne Later fresh glands were substituted these were more readily taken than the dried ones

Branham used subcutaneous injections of emulsions of beef parathyroid with success in a case following operation for goiter, the tetany disappeared permanently after a second injection It is evident that this patient would have recovered without the parathyroid treatment

Schneider reported a case of postoperative tetany in which the administration of the dry parathyroid of the horse (0 02 gram in two days) was followed by improvement the symptoms later reappeared but disappeared after 0 03 gram of parathyroid Other favorable reports have been published by Bircher Rossiysky and others Eschrich, Frankel Hochwart Pineles Rensburg and others report negative results from parathyroid therapy in human parathyroid tetany

Several cases have been reported in which relief or cure of postoperative tetany followed transplantation of the gland Leischner and Kohler obtained only temporary relief from transplantation in one case and no results in another They suggest that in some of the apparently successful cases in transplantation in man there was a regeneration or recovery of function by the remnants of parathyroid tissue of the patient

Parathyroid has been administered with inconclusive results in a number of other forms of tetany and in other conditions, the influence of suggestion has not always been eliminated Haskins and Gerstenberger obtained no effects from parathyroid and calcium administration in one case of infantile tetany

Berkeley relieved the symptoms of *gastric tetany* by the administration, by mouth, of fresh beef parathyroids, Moffitt also reports favorable results from the use of the dried powder and later from hypodermic injections of the nucleoproteid of beef parathyroids

Loewenthal and Wiebrecht obtained good results from parathyroid feeding in infantile tetany, but others have reported entirely negative results

Berkeley reports better results from the administration of parathyroid in *paralysis agitans* than from any other remedy Of twenty six cases treated, five were not benefited, three showed temporary improvement, and eighteen grew progressively better during the whole period of treatment Roussy and Clunet observed slight temporary improvement in two cases, a distinctly bad effect in two others, and no effect in a fifth case They report a condition of parathyroid hyperplasia (whether primary or secondary not determined) in this disease Oppenheim recommends the administration of doses corresponding to 0 0 gram of the fresh gland several times a day

Favorable results have been reported from the use of parathyroid in eclampsia, epilepsy, idiocy, and chorea—especially in adults (Garavini) It will be recalled that several clinicians have reported favorable effects from the use of *thyroid extract* in eclampsia, on the theory that this type of tetany is due to thyroid deficiency (Nicholson, Sturmer)

Morris reports injurious effects following prolonged administration of parathyroid gland by mouth In a patient with paralysis agitans the feeding produced disturbing mental symptoms and insomnia, but no improvement of the paralysis agitans

SUMMARY

1 Parathyroid deficiency in man and experimental animals leads to chronic nervous hyperexcitability, occasional tetany, and some cachexia Total loss of the parathyroids leads to death in from two to fifteen days in tetany or extreme cachexia especially in carnivorous animals The primary disturbance following parathyroid ablation appears to be due to a toxemia, primarily of the intestinal (putrefaction) origin, and accumulation of toxic protein derivatives in the blood

2 All therapeutic measures that temporarily reduce the excitability of the nervous system will diminish or prevent parathyroid tetany temporarily, but they cannot save the life of the patient or the experimental animal in total absence of the parathyroids The tetany is controlled and life prolonged indefinitely by diets that render the intestinal flora aciduric, by marked diuresis, and by feeding large quantities of calcium lactate but these surviving animals are in a state of latent tetany

3 No definite causal relation between parathyroid deficiency and

eclampsia, infantile tetany, gastro-intestinal tetany, paralysis agitans, idiopathic epilepsy etc, has been so far established The reports on parathyroid organotherapy in these maladies are so conflicting and unsatisfactory that no reliance can be placed on the few favorable results recorded Parathyroid organotherapy in these conditions is at present purely experimental and empirical

4 The results to date on man and experimental animals indicate that true parathyroid tetany cannot be controlled even temporarily by giving parathyroid gland by mouth or by transfusion of normal blood The hypodermic or intramuscular administration of parathyroid extracts is of doubtful value even as a temporary measure, and animal experiments show conclusively that such administration fails to prevent death in tetany or cachexia in the total absence of parathyroid In light of our present experimental and clinical experience parathyroid transplantation is the most promising therapy in all types of parathyroid deficiency, while diet diuresis and lime salts *per os* merely control the conditions The extremely conflicting results of parathyroid organotherapy both in man and animals, are probably due to the frequency of accessory parathyroids so that alleged complete parathyroidectomy is in many cases, only partial parathyroidectomy with temporary nervous hyperexcitability and tetany symptoms According to the researches of Halsted and others, such parathyroid remnants will undergo hypertrophy and may finally meet the entire need of the organism in which case the animal or the patient recovers permanently Any therapy of such temporary tetany conditions will be successful, by *post hoc* reasoning although it has nothing to do with the recovery of the animal or the patient except such measures as may temporarily check the hyperexcitability of the nervous tissue

5 With the modern care in thyroid surgery cases of definite parathyroid deficiency in man become less frequent Parathyroid organotherapy of other types of clinical tetany will contribute little or nothing to medical progress until further advances have been made in the physiology pathology and chemistry of the parathyroid glands But the dietary diuretic and calcium lactate therapies of Dragstedt and Luckhardt may prove beneficial in these disorders

THE PANCREAS

In 1889 von Mering and Minkowski discovered that complete extirpation of the pancreas in the dog produces fatal diabetes This has been abundantly confirmed on all species of vertebrates so far investigated The attempts of Pfluger and others to show that the diabetes following removal of the pancreas is due not to the absence of the pancreas but to

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4. The results to date on man and experimental animals indicate that true parathyroid tetany cannot be controlled, even temporarily, by giving parathyroid gland by mouth or by transfusion of normal blood. The hypodermic or intramuscular administration of parathyroid extracts is of doubtful value even as a temporary measure, and animal experiments show conclusively that such administration fails to prevent death in tetany or cachexia in the total absence of parathyroid. In light of our present experimental and clinical experience, parathyroid transplantation is the most promising therapy in all types of parathyroid deficiency, while diet, diuresis and lime salts *per os* merely control the conditions. The extremely conflicting results of parathyroid organotherapy both in man and animals are probably due to the frequency of accessory parathyroids, so that alleged complete parathyroidectomy is in many cases only partial parathyroidectomy with temporary nervous hyperexcitability and tetany symptoms. According to the researches of Halsted and others such parathyroid remnants will undergo hypertrophy and may finally meet the entire need of the organism, in which case the animal or the patient recovers permanently. Any therapy of such temporary tetany conditions will be successful by *post hoc* reasoning, although it has nothing to do with the recovery of the animal or the patient, except such measures as may temporarily check the hyperexcitability of the nervous tissue.

5. With the modern care in thyroid surgery, cases of definite parathyroid deficiency in man become less frequent. Parathyroid organotherapy of other types of clinical tetany will contribute little or nothing to medical progress until further advances have been made in the physiology, pathology and chemistry of the parathyroid glands. But the dietary, diuretic and calcium lactate therapies of Dragstedt and Luckhardt may prove beneficial in these disorders.

THE PANCREAS

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injury to the duodenum and the nerves connecting the pancreas with the rest of the viscera, must be considered a failure The original conclusion of von Mering and Minkowski is definitely established The complete or nearly complete loss of the pancreas results in fatal diabetes The more recent investigations of the condition of the pancreas in clinical diabetes (Opie, Allen and others) have shown that in severe diabetes or in deaths in diabetes there is usually more or less degeneration of the pancreas, especially in the island tissue The conclusion that the pan

FIG 5—MICROPHOTOGRAPH (× 38) OF A PORTION OF THE PANCREAS OF THE GUINEA PIG STAINED INTRA VITAM BY NEUTRAL RED This shows the normal variations of the size and frequency of the islands of Langerhans—dark areas (Bensley)

creas is absolutely essential to life and to carbohydrate metabolism is thus based on experimental and clinical data, and established beyond a doubt

The part of the pancreas concerned in this function appears to be essentially the *islands of Langerhans* This seems to be demonstrated by the following facts

1 Loss of the external pancreatic secretion (by permanent fistula of the pancreatic ducts) does not induce diabetes

2 Ligation of all the pancreatic ducts leads ultimately to complete

degeneration of all the pancreas tissue except the islands of Langerhans—at least in animals like the rabbit and guinea pig Such animals with only islet tissue left do not develop diabetes unless these remnants of the pancreas are extirpated

3 In clinical diabetes the pancreatic lesions usually involve the islets Despite these facts the view that the entire pancreas tissue is concerned in the maintenance of the capacity of the tissues to oxidize the carbohydrates is still maintained by some clinicians and biologists This view finds its strongest support in the fact that human diabetes may reach a fatal issue while there still remains an abundance of apparently normal island tissue in the pancreas as determined histologically It is possible however that normal function is reduced or lost before anatomical or chemical degeneration of the cells reach such magnitude that they can be detected by the microscope This theory of identity of function of the entire pancreas was also supported by the work of Dale Vincent and Thomson and others which appeared to show that the islets represented only stages of fatigue or rest of the ordinary pancreas tissue Laguesse Bensley, and others have shown that this is untenable While the islets and the acini develop from the same embryological anlage (the cells of the ducts), when finally differentiated they show constant and specific structural and chemical characteristics, evidently indicating specificity of function and there is no foundation for the view that the one tissue is or can be transformed into the other

The Islands of Langerhans—The number and size of the islets vary greatly in different species, as well as in individuals of the same species In some fishes they are macroscopic, and separated from the rest of the pancreas In man the islets have been estimated to make up one twenty fifth to one one-hundredth part of the entire pancreas tissue or a total of 2 3 grams In a normal animal five sixths of the total pancreas can be removed without inducing diabetes, so that the factor of safety' is very great The total number of islands in mammals appears to be fixed at, or rather before birth (Bensley)

Lane and Bensley have shown that the island tissue is made up of two distinct types of cells, showing specific staining reactions a less abundant *alpha type* and a more numerous *beta type* According to Homans it is the beta cells that show degeneration changes in clinical diabetes

The islets develop from the undifferentiated duct cells and may or may not retain this original connection with the ducts but in either case the blood supply of the islets is greater than to the rest of the pancreas tissue In this respect the islets resemble the adrenals and the thyroids In fact blood sinuses similar to those of the adrenals have been described in the islets (DeWitt)

The islets are also abundantly supplied with nerve fibers (Gentes, Pensa, Laguesse) Groups of ganglion cells are also distributed in the body of the pancreas The function of the nerves distributed to the islets is unknown Some of them are undoubtedly vasomotor nerves but others form a network between or around the islet cells, which appears to indicate a secretory or reflex function

Experimental Pancreatic Diabetes—Extirpation of the whole or more than six sevenths of the pancreas leads to fatal diabetes in all animals In birds pancreatectomy leads to hyperglycemia, cachexia, and

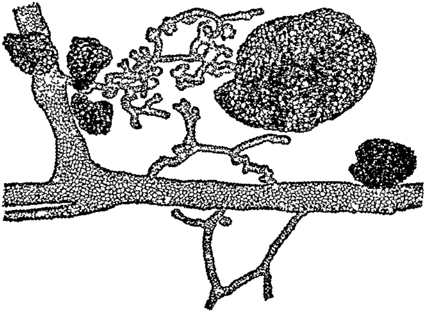

FIG 6—PANCREATIC DUCT WITH BRANCHES SHOWING THE HIGHLY BRANCHED TUBULES CONNECTED WITH THE DUCT AND WITH AN ISLET Intra vitam staining with pyronin and neutral red × 74 (Pensley)

death but there is said to be little or no glycosuria, because of the relative impermeability of the renal epithelium of birds to sugar

Following the fundamental discovery of pancreatic diabetes by von Mering and Minkowski in 1889 a great amount of work had been done to elucidate the nature or mechanism of this diabetes (cf Allen, 1914) The following facts are established

1 Hyperglycemia and glycosuria appear within a few hours after pancreatectomy and together with polyuria polyphagia and polydipsia persist until shortly before death, even when no food is given If the hyperglycemia of human or experimental diabetes is sufficiently marked, the sugar appears in the saliva gastric and pancreatic juice and in the bile (Carlson and Ryan Pearce)

2 The liver and the muscles become practically free from glycogen, but the essential factor appears not to be the inability to store glycogen (alimentary glycosuria) but a *greatly diminished capacity if not complete inability to oxidize the sugar* It is of course possible that all carbohydrates must first be built up into animal starch or glycogen before oxidation, but this seems improbable since this implies some structural differences in the glucose molecule before and after being a member of the glycogen complex and we have as yet no evidence that this is the case The respiratory quotient is therefore low (Murlin and Kramer) Nishi states that perfusion of the liver of pancreatectomized turtles with Ringer's solution plus glucose leads to storage of glycogen in the liver cells.

3 There is marked polyphagia (Luckhardt) and a striking increase (15 to 20 per cent) in the total metabolism per unit of body weight (Morehouse, Patterson, and Stephenson) There is no rise in the respiratory quotient after giving glucose or fructose The increased excretion of the acetone bodies parallels the increase in the D N ratio

4 There is usually some acidosis and ketonuria, but these symptoms of diabetes are, at least in the dog not as marked as in clinical diabetes and the completely pancreatectomized animals die apparently from extreme inanition or from intercurrent infections rather than in diabetic *coma due to acidosis*

5 When the pancreas remnant is too small to maintain normal sugar tolerance and metabolism, the pancreas rest is more likely to undergo gradual atrophy than to show hypertrophy with the end result of absolute and fatal diabetes (Sandmeyer) The incomplete diabetes in animals following extirpation of more than 80 per cent of the pancreas can apparently be intensified, and the appearance of complete diabetes and death hastened by a liberal carbohydrate diet (Thiroloix, Allen Carlson and Jensen)

6 Complete pancreatectomy leads to death in from three to eight weeks, in the case of dogs, irrespective of the age of the animal (Carlson), while diabetes mellitus is usually more rapidly fatal in children than in adults and in old people

7 The persistent hyperglycemia and glycosuria and the low respiratory quotient show that the pancreatectomized animal burns practically no sugar yet the study of the sugar oxidation capacity of the blood and of individual tissues like skeletal muscles and the heart have so far revealed no difference between the normal and the diabetic animal (Claus and Embden MacLean McGuigan Patterson and Starling Macleod and Pearce) The respiratory quotient of the dog's heart averages 0 71 irrespective of whether the heart is that of a diabetic or a normal dog (Starling and Evans) But Hepburn and Latchford have recently reported that adding a purified pancreatic extract (insulin) to the perfusing fluid

The islets are also abundantly supplied with nerve fibers (Gentes, Pensa, Laguesse). Groups of ganglion cells are also distributed in the body of the pancreas. The function of the nerves distributed to the islets is unknown. Some of them are undoubtedly vasomotor nerves, but others form a network between or around the islet cells, which appears to indicate a secretory or reflex function.

Experimental Pancreatic Diabetes.—Extirpation of the whole or more than six sevenths of the pancreas leads to fatal diabetes in all animals. In birds pancreatectomy leads to hyperglycemia, cachexia, and

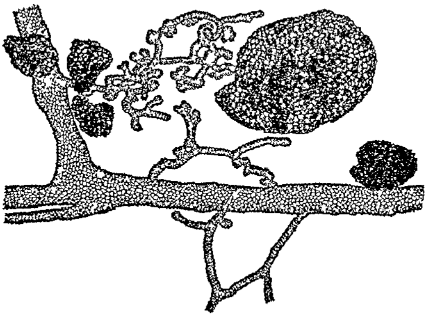

FIG. 6.—PANCREATIC DUCT WITH BRANCHES SHOWING THE HIGHLY BRANCHED TUBULES CONNECTED WITH THE DUCT AND WITH AN ISLET. *Intra vitam staining with pyronin and neutral red.* × 77. (Bensley.)

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Following the fundamental discovery of pancreatic diabetes by von Mering and Minkowski in 1889, a great amount of work had been done to elucidate the nature or mechanism of this diabetes (cf. Allen, 1914). The following facts are established:

1. Hyperglycemia and glycosuria appear within a few hours after pancreatectomy and, together with polyuria, polyphagia and polydipsia, persist until shortly before death, even when no food is given. If the hyperglycemia of human or experimental diabetes is sufficiently marked, the sugar appears in the saliva, gastric and pancreatic juice, and in the bile (Carlson and Ryan, Pearce).

very low in the pig and the sheep (Carlson and Drennan, Hunter and Hill). In normal persons four hundred to five hundred grams of glucose may be given by mouth without inducing polyuria or glycosuria (Taylor and Hulton). In normal men and animals the oxidation of sugar is increased in proportion to the quantity of sugar given intravenously up to a very high limit (Woodyatt).

The endeavor to determine how absence of the pancreas causes diabetes is practically a record of repeated failures. The leading idea in all this work has been the internal secretion theory, or that the pancreas yields some substance to the blood in some way necessary for the oxidation of the sugar by the tissue cell. The new method of attack introduced by Cohnheim has not yielded consistent results (Claus and Embden, McGuigan) and in the light of the findings of Levene and Meyer the method itself is called in question, as it appears that in a mixture of muscle extract and pancreas extract glucose is polymerized, not oxidized. No light on pancreatic diabetes has so far been shed by studying the sugar oxidizing power of tissue debris or tissue extracts.

Blood Transfusion.—If the pancreas controls the oxidation of sugar in the tissue by a hormone or hormones, these must be present in the blood, and unless they are extremely unstable or present in very minute traces, it should be possible to increase temporarily the sugar oxidation in diabetic animals and patients by transfusion of normal blood in sufficient quantities. But the results obtained by this method are both conflicting and difficult to interpret.

Lépine reports a temporary diminution in the output in the urine, but no diminution in the blood sugar. This would seem to point to some injurious action of the foreign blood on the kidneys—a suggestion also advanced by Hedon—but Kabens has shown that transfusion of normal blood into diabetic dogs does not influence the output of any of the urinary constituents except the sugar. Hess injected intravenously 50 to 150 c.c. of blood from diabetic dogs into normal dogs (on the theory that diabetic blood might stimulate the pancreas to a greater output of internal secretion) and nine to fourteen hours later he injected the serum from this animal into diabetic dogs. The influence on the glycosuria of the diabetic animal was slight or inconstant. In view of the results of Drennan, it seems likely that in the experiments of Hess the pancreas secretion in the blood was destroyed by the delay in centrifuging the blood. Alexander and Ehrmann injected blood from the pancreaticoduodenal vein of normal dogs into diabetic dogs but obtained no definite or constant decrease of the glycosuria.

Drennan injected 50 to 150 c.c. of fresh defibrinated dogs' blood into the veins of diabetic dogs and invariably obtained a temporary lowering of the urine sugar and the D : N ratio. Defibrinated sterile blood loses this action on standing for a few hours. The course of the blood sugar

increases the glucose consumption of the excised and perfused mammalian heart

Certain other features of experimental pancreatic diabetes may be noted Epstein and Baehr claim that there is an increase in the blood volume (plasma) in dogs and cats after pancreatectomy, irrespective of whether the animal is fed Hoskins and Gunning state that in dogs after complete pancreatectomy the blood pressure remains either normal or somewhat depressed Reaction to adrenalin is usually augmented, to nicotin variable but usually depressed There is no evidence that the pancreas normally exerts a depressive action on the sympathetic nervous system They found no evidence of increase in the adrenalin content of the adrenals after pancreatectomy

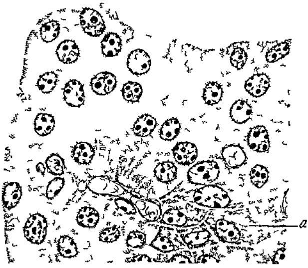

FIG 7 —SMALL PORTION OF AN ISLET OF LANGERHANS OF THE GUINEA PIG Shows *B* cells filled with fine granule and A cell stained diffusely *a* A cells × 1000 (Bensley)

Verzar and Fejer claim that administration of glucose during the first three to four days after pancreatectomy raises the respiratory quotient This, if true would indicate that the pancreas hormone persists in the blood and tissues for several days This is probable It must be remembered, however, that all the sugar of the food or from the endogenous protein metabolism does not appear in the urine even in animals and patients showing the D N ratio of 3 65 1, which Lusk has designated as the index of absolute diabetes It is not known what becomes of the retained sugar In diabetic patients "the respiratory quotient fails to account for all the carbohydrates that disappear in the body' (Allen and DuBois)

Numerous attempts have been made to explain the glycosuria of diabetes by the increased rate of liberation of the sugar from some hypothetical sugar protein or sugar colloid combinations in the blood The dialysis experiments of Van Hess and McGuigan seem to demonstrate that all the sugar in the blood is present in simple solution, that is, in free form

The carbohydrate tolerance varies greatly in different species It is

is subsequently eliminated by the kidneys as excess sugar as suggested by Murlin

The blood transfusion as such does not impair the kidneys activity in any demonstrable way, either in diabetic or in normal dogs The temporary lowering of the glycosuria of pancreatic diabetes by transfusion of normal blood is due to the diminished hyperglycemia not to kidney injury but it remains to be demonstrated that this retained sugar is actually oxidized by the tissues

Parabiosis—Experimental symbiosis or parabiosis of two mammals is accomplished usually by union of the skin and the abdominal walls of two sisters or brothers It was originally thought that such union of two animals would lead to a direct vascular connection between the two, but it is now known that this is not the case There is no fusion of the capillary systems of the two animals in the region of the tissue union but the capillary systems of the two animals are in so close contact that chemical substances injected into one animal soon appear in the blood of the other animal On the basis of this fact one may reasonably expect that the blood hormones of one animal will find their way into the body fluids of the other animal On this theory Forsbach extirpated the pancreas of one member of two such parabiotic pairs (dogs) In every case a slight temporary glycosuria appeared in both animals But because of accidents both experiments were terminated before definite results were obtained

Pregnancy—It was shown by Pearce that the islets of the pancreas appear early in fetal life There appears to be no diabetes or glycosuria in human infants born two or three months before term. This would seem to show that the pancreas hormones become of functional importance to the fetus a considerable time before the end of gestation On the basis of these facts Carlson, Drennan, Orr, and Ginsburg made complete pancreatectomy in pregnant bitches near term *In all cases where this operation is not followed by abortion the blood sugar and the urine remain normal until the pups are born or removed by cesarian section* Complete pancreatectomy in bitches in early pregnancy leads to abortion or at least to death of the fetuses in one or two weeks and the course of the diabetes is not influenced

This absence of diabetes may be due either to the pancreas hormones of the fetuses passing into the mother's blood or to some detoxicating action on the part of the fetal pancreas

There is a seeming discrepancy between these results on pregnant dogs and the usual clinical experience on the effects of pregnancy on the course of diabetes in the human The clinical experience appears to be unanimous on the point that pregnancy augments the diabetic symptoms, and hence the practice of terminating gestation in diabetic mothers Now, even if in their primary cause all cases of diabetes mellitus are identical

in the injected animals was not studied Hedon has reported a very extensive series of blood transfusions in diabetic dogs Direct transfusion from a normal dog into a diabetic dog previously bled dry causes a temporary lowering of the blood sugar and decrease or complete suppression of the glycosuria but, since the same results were produced when blood from a diabetic dog was transfused into another diabetic dog, Hedon concludes that the temporary diminution of the hyperglycemia and glycosuria following the transfusion was not due to any specific pancreas secretion in the blood but to a lowering of the blood sugar by dilution and *to a toxic action of the foreign blood on the kidneys* The results of the cross transfusion experiments reported by Hedon do not concern us here, since these may be interpreted in various ways (detoxication of the pancreas, storage of glycogen in the normal animal, dilution of the diabetic blood etc) Hedon also transfused (cross transfusion as well as serum injections) blood from the pancreatic vein of normal to diabetic dogs A slight temporary lowering of the hyperglycemia with a greater reduction of the urine sugar was noted, but the latter is interpreted as due to an injurious action of the foreign blood on the kidneys Hedon concludes that the internal secretion of the pancreas acts on and is absorbed by the liver and is, therefore, not present in the blood of the systemic circulation Hedon attempted to obtain evidence in support of this view by introducing a living pancreas in the systemic and in the portal circulation of diabetic dogs With the living pancreas interposed in the portal circulation the hyperglycemia and glycosuria were diminished, but when it was interposed in the general circulation the pancreas had no effect

We do not think that these latter results of Hedon can be accepted, in view of what is known concerning the carbohydrate metabolism in dogs *with Eck fistula In the animal with the Eck fistula the internal secretion* of the pancreas, if there is one, must pass into the general circulation, and only a small part of it can reach the liver by way of the hepatic artery, just as in Hedon's diabetic dogs with the living pancreas from another dog interposed in the general circulation, yet the Eck fistula dog does not develop diabetes.

Murlin and Kramer *reported one experiment with transfusion* of normal blood into a diabetic dog showing slight rise in the respiratory quotient, as a measure of sugar oxidation

Carlson and Ginsburg found that the transfusion (without anesthesia or previous hemorrhage) of normal *blood* into *dogs* in *complete pancreatic* diabetes causes a temporary (four to eight hours) lowering of the hyperglycemia and the glycosuria Similar transfusions of diabetic blood into diabetic dogs have no effect on the hyperglycemia There was no indication in these results that the sugar retained by the animal in consequence of this temporary *lowering* of the *sugar excretion by* the *kidneys*

is subsequently eliminated by the kidneys as excess sugar as suggested by Murlin

The blood transfusion as such does not impair the kidneys activity in any demonstrable way, either in diabetic or in normal dogs The temporary lowering of the glycosuria of pancreatic diabetes by transfusion of normal blood is due to the diminished hyperglycemia not to kidney injury *but it remains to be demonstrated that this retained sugar is* actually oxidized by the tissues

Parabiosis—Experimental symbiosis or parabiosis of two mammals is accomplished usually by union of the skin and the abdominal walls of two sisters or brothers It was originally thought that such union of two animals would lead to a direct vascular connection between the two, but it is now known that this is not the case There is no fusion of the capillary systems of the two animals in the region of the tissue union but the capillary systems of the two animals are in so close contact that chemical substances injected into one animal soon appear in the blood of the other animal On the basis of this fact one may reasonably expect that the blood hormones of one animal will find their way into the body fluids of the other animal On this theory Forsbach extirpated the pancreas of one member of two such parabiotic pairs (dogs) In every case a slight temporary glycosuria appeared in both animals But because of accidents both experiments were terminated before definite results were obtained

Pregnancy—It was shown by Pearce that the islets of the pancreas appear early in fetal life There appears to be no diabetes or glycosuria in human infants born two or three months before term This would seem to show that the pancreas hormones become of functional importance to the fetus a considerable time before the end of gestation On the basis of these facts Carlson, Drennan, Orr, and Ginsburg made complete pancreatectomy in pregnant bitches near term *In all cases where this operation is not followed by abortion the blood sugar and the urine remain normal until the pups are born or removed by cesarian section* Complete pancreatectomy in bitches in early pregnancy leads to abortion or at least to death of the fetuses in one or two weeks and the course of the diabetes is not influenced

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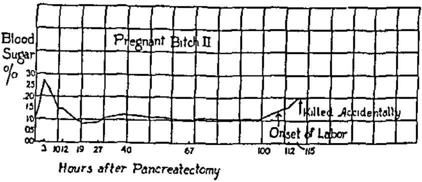
with that of experimental pancreatic diabetes, the favorable action of the fetal pancreas on the mother would come only late in pregnancy, and the disturbances in digestion, circulation, and emotional states, etc., of the first half of pregnancy would undoubtedly act unfavorably. But, so far as we have been able to learn, the unfavorable action of pregnancy on clinical diabetes during the second half of gestation is even greater than during the first half. If this is true, it would seem to indicate a primary difference in the etiology of diabetes in man and of



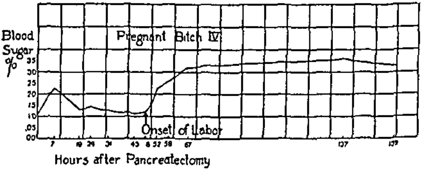


Fig. 8.—Charts Showing Absence of Hyperglycemia and Diabetes after Complete Pancreatectomy in Late Pregnancy. Diabetes begins at onset of labor. (Carlson and Ginsburg.)

experimental pancreatic diabetes in other mammals. The difference, however, may be only apparent. If the diabetes in the mother is caused by the depression of the pancreas by some substance in the blood, or by the *inhibition or neutralization of pancreatic secretion* by substances in the blood rather than by actual atrophy of islet tissue, these substances in all probability would act in the same way on the fetal pancreas or pancreatic hormones, thus giving the usual clinical findings.

Transplantation of the Pancreas.—Most of the transplantations of the pancreas *have been mere dislocation* of a portion of it, the usual method being the transplantation of the tail of the pancreas with *its cir*

culation intact to other parts of the abdominal cavity or even under the skin of the abdomen. If a sufficient quantity of the pancreas is thus dislocated or transferred and care is taken to retain the circulation in good condition at least for a time, the remainder of the pancreas may be extirpated without inducing diabetes (Thiroloix, Hedon, Lombroso, Minkowski). But in most cases even these transplants show a tendency to atrophy with a gradual onset of diabetes and ultimate death in complete diabetes. The external ferments of the pancreas are probably in part responsible for this gradual necrosis of the graft. There is no record in the literature of transplantation of pure island tissue. There is certainly greater hope of success with such tissue than with the entire pancreas. Pflüger failed to influence the diabetes of depancreatized frogs by inserting pieces of the pancreas under the skin or in the peritoneum. Pratt reports the case of one pancreas autotransplant into the spleen (dog) that retained its function (absence of diabetes) for six months. But there is little hope of pancreas transplantation becoming of significant value in clinical diabetes, *since it seems at present impossible to keep grafts of any gland permanently functional.*

Feeding Pancreas or Pancreas Extracts.—Feeding dogs in complete or partial pancreatic diabetes with fresh pancreas increases the glycosuria and acidosis (Sandmeyer, Pflüger, Luthje, Reach, Rosenberg, Kirk). Cooked pancreas gives equally negative results. Feeding of raw muscle, liver, or other tissue extracts has the same unfavorable influence on the glycosuria and ketonuria. Ausset and particularly Pratt, Spooner and Murphy report good effects from feeding pancreas in partially diabetic dogs, but the improvement in the carbohydrate tolerance was slight, variable and practically negligible. According to Massaglia, feeding pancreas extract to guinea pigs with experimental reduction of the pancreas reduces or prevents the alimentary glycosuria following carbohydrate food.

Injection of Pancreas Extracts.—Up to the year 1921 subcutaneous or intraperitoneal injections of extracts of the pancreas variously prepared caused temporary diminution of the glycosuria in diabetic animals (Caparelli, Vanni, Tiberti and Franchetti, Minkowski, Hedon, Zuelzer, Scott, Allen, Murlin and Kramer, and others). But this temporary diminution of the output of sugar in the urine was associated with toxic effects such as depression, fever, etc., and McGuigan showed that almost anything which causes marked systemic depression (such as injection of proteoses) leads to hypoglycemia and will thus temporarily diminish an existing glycosuria. Underhill reports diminution of glycosuria in dogs by hydrazin. Knowlton and Starling and Maclean and Smedley reported that the sugar oxidation of the heart from diabetic animals is almost nil, and in any event much less than that of a heart from a normal animal, but further work has shown these results to be due to faulty technic (MacLeod and Pearce, and Patterson and Starling). Extract of the

pancreas added to the perfusion solution has no effect on the respiratory quotient of the diabetic heart (Starling and Evans)

This was the unsatisfactory state of our scientific work when, in 1921, Banting and Best renewed the investigations of pancreas extracts, with promising results They first made extracts of the fetal pancreas, and of pancreas rendered atrophic by ligation of the ducts, in order to eliminate the external pancreatic secretion These extracts reduced the hyperglycosuria of diabetic animals Later, in collaboration with Collip, acid and alcohol extracts were made of the normal adult pancreas that similarly reduced the hyperglycemia of diabetes and lowered the blood sugar in normal animals The extract, or rather the active substance in the extract, has been named *insulin* Insulin has so far not been prepared in pure state nothing is known of its composition, although Macleod has reported that active extracts can be prepared that give no reactions characteristic of proteins The extract is toxic, but according to Macleod, at least part of this toxicity is due to the active substance, insulin, that is to the excessive hypoglycemia caused by excessive doses of the insulin The experimental results to date (January, 1923) reported by Banting, Best and their collaborators and workers in other institutions can be summarized thus

1 The pancreas extract, insulin, lowers the blood sugar both in diabetes and normal animals This seems to be due to two processes (1) increased formation of glycogen by the liver and the muscles, and (2) increased oxidation of sugar, as shown by the rise in the respiratory quotient This action of the extract is temporary (6 to 8 hours)

2 Continued administration of the extract seems to maintain nutrition and prolong the life of depancreatized dogs, but the work on this phase is not yet conclusive

3 The extract has little or no effect when given by mouth or *per rectum* It must be administered parenterally

4 The toxic effects (depression, convulsion, death) from large doses are assumed to be due to the hypoglycemia, since these effects can be, at least in part, prevented by the administration of glucose

5 The insulin does not seem to be entirely specific for the pancreas, as extract producing some hypoglycemia can be secured from other organs by identical methods of preparation But Macleod reports that, in fishes, insulin is obtained from the island of Langerhans and not from the pancreas proper

6 Some fraction of the pancreas extracts actually produces hyperglycemia in normal animals (Fisher)

Pancreas Hormones in Pancreatic Perfusates—Clark placed the pancreas in the perfusion circuit of an excised heart, perfused with Locke's

olution containing known quantities of glucose He reported that under these conditions the heart consumed more glucose than did the heart without a surviving pancreas in the circuit Clark interpreted this as proving that the pancreas secreted into the perfusate some substance that accelerated the sugar oxidation by the heart Landes, *et al* perfused the excised pancreas with Tyrode s solution for varying periods and injected the perfusate intravenously into diabetic dogs There was no reduction of the hyperglycemia and glycosuria There is no evidence that the excised pancreas perfused with a Ringer sugar solution is sufficiently normal to secrete the hormone Clark s results might be explained by death and solution of the island cells It is well known that perfusion of organs with salt solutions quickly induce pathological changes (edema)

The perfusate takes up depressor substances (peptones?) from the pancreas In order to eliminate these sources of error McCarthy and Olmstead, in our laboratory, perfused the excised pancreas (using the Woodyatt pump) of the dog with defibrinated blood from the same animal, and then injected the blood intravenously into diabetic dogs Control experiments were made by perfusing the excised spleen In other control experiments active secretin was added to the defibrinated blood in order to see whether the excised and perfused pancreas was sufficiently alive and normal to secrete pancreatic juice In most cases a slight secretive response (a few drops) was obtained but this was much less than the usual response of the intact pancreas to similar doses of secretin It is, therefore clear that even when the excised pancreas is perfused with blood the pancreas is so abnormal or depressed that it is doubtful if any normal function is present Intravenous injection of this pancreas perfusate into diabetic dogs usually lowered the hyperglycemia, but did not constantly lower the D N ratio of the urine That these were toxic rather than physiological effects seems to be shown by the fact that identical results were produced by the spleen perfusate It would seem that perfusing the excised pancreas leads to demonstrable quantities of the pancreas hormone in the perfusate only to the extent that island cells are killed and extracted

Relation of Pancreatic Diabetes in Animals to Clinical Diabetes —In their essential features experimental and clinical diabetes are practically identical There is the same impairment of the power to burn sugar, the identical hyperglycemia tendency to acidosis lowered resistance to infection polyphagia, etc The two types of diabetes are influenced in the same direction by diabetic and therapeutic measures (Allen) All the evidence points to the view that diabetes mellitus in man is primarily due to deficiency or inhibition of pancreatic hormones This does not apply to the various glycosurias (adrenalin nervous, alimentary, post operative, etc) which do not involve impairment of sugar oxidation

Administration of Pancreas Preparation (Insulin) in Clinical Diabetes by the Mouth—Some of the earliest attempts to treat diabetes mellitus organotherapeutically were by the administration of the pancreas by the mouth, it was largely abandoned very early, for the results were practically negative (Mackenzie, Wood, White, de Cerenville, Willis, Williams, Rennie and Fraser Pratt, Wood, Marshall)

A few writers (Wegele Meyer, Cowles and Eustis) have reported favorable results Some of these reports contain only impressions, in others the glycosuria seemed dependent upon an infection and varied so much in severity that it is difficult to determine what, if any, effect the treatment had In Cowles' case the diabetes had followed an abscess of the pancreas marked and rapid improvement is stated to have followed the eating of one to six (average three) raw pancreases of calves daily After discontinuing the treatment the patient became rapidly worse and died as he probably would have done had the pancreas feedings been kept up

Rennie and Fraser administered the islands of Langerhans obtained from fish of certain species in which they occur separately, that is distinct from the pancreas proper, to a number of diabetics, the results were negative

Sewall found in the earlier stages of one case of youthful diabetes that the urine could be made free of sugar by the administration by mouth of infusions of raw, lean beef followed after some hours, by one of pancreas neither alone was efficacious and after some months the combined treatment failed The method was ineffective in a number of other cases No good results attended the use of the commercial pancreatic powder

Under the influence of the first report of Knowlton and Starling on the effect of pancreas extract on the sugar consumption of the diabetic heart, Eustis administered 10 to 20 grains of an "active extract of the pancreas" every four hours on an empty stomach in four cases of diabetes He reports diminution of the glycosuria in two of the patients and no effects in the others The *insulin* of Banting and Best appears to have no effect when given *per os* or *per rectum* or by means of the duodenal tube

There is, however, according to Falta, a small group of cases of human diabetes in which the administration of pancreas by mouth gives good results *this is the result of supplying the external and not the internal secretion of the gland* Falta refers to those cases in which the pancreas is diseased, so that there is no longer an adequate secretion of pancreatic juice into the intestine this occurs most frequently when there is complete obstruction of the pancreatic duct In such cases Falta states that the administration of large doses (10 grams daily) of pancreatin gives excellent results According to Cody and Rooper, feeding

pancreas vitamin to marasmic children stimulates growth and improves nutrition. This is food therapy, not organotherapy.

Subcutaneous and Intravenous Injections of Pancreas Preparations.—A number of attempts have been made to treat diabetes by subcutaneous and intraperitoneal injections of extracts of pancreas with negative or injurious results. The favorable results reported by some of the earlier clinicians were shown by Pfluger and by Leschke to be wholly inconclusive. The more recent attempts of Zuelzer to treat the disease by the intravenous injection of a pancreas hormone was given up largely because of toxic effects of the extract. During the last year the insulin of Banting and Best has been tried on selected cases of human diabetes in the United States and Canada. It is too early to reach definite conclusions as to the ultimate value of insulin, but so far the results are encouraging (Banting *et al.*). In sufficiently large doses three times per day (hypodermatically) insulin seems to control all the symptoms in most diabetic people and permit a larger food intake. Some diabetics are less favorably influenced by insulin. These may not be cases of pancreatic diabetes. The main drawback to the insulin treatment is the toxicity of the extract and the necessity of such frequent hypodermic administration. Dietary control will probably always be a factor in the management of diabetes, unless insulin therapy for shorter periods may increase the carbohydrate tolerance more or less permanently.

Fortunately, few attempts have been made to treat human diabetes by transplantation of the pancreas. Futcher states that Williams of Bristol transplanted the pancreatic gland of a sheep under the skin of the breast and abdomen of a diabetic. The patient died of coma in three days.

Blood Transfusion.—Ralston and Woodyatt appear to be the first to try blood transfusion as a practical therapeutic measure in man. The patient was a man in the thirties, the diabetes of several years standing with periods of threatening coma. The blood (600 c.c.) was yielded by a two year older brother of the patient. The experiment was well controlled. *The blood transfusion augmented all the diabetic symptoms for several days following the operation.*

Relation of Other Endocrine Glands and Organs to Experimental and Clinical Diabetes.—In 1908 Eppinger, Falta and Rudinger advanced the theory that diabetes is not due primarily to the hypofunction of any one endocrine gland (for example, the pancreas) but to a disturbance of the hormone equilibrium of all the glands—particularly that of the pancreas, thyroid, adrenals and hypophysis. This view is still held by some (Brown, Hatai). The specific influence on carbohydrate metabolism of hypofunction and hyperfunction of the adrenals, thyroid and hypophysis are discussed in the sections on these glands respectively. It now remains to consider whether the hypofunction or hyperfunction of any other organ beside the pancreas is capable of so reducing the capacities of the

tissues to store and oxidize sugar that true diabetes follows A critical analysis of the entire literature, experimental and clinical, seems to warrant the following conclusions

1 Hypo activity of the thyroid, the hypophysis and the gonads may slightly change carbohydrate tolerance, although further studies should be made on this question by Woodyatt's more accurate method of measuring sugar oxidizing capacity If true, this may be in reality a thyroid factor, as there is some indication of hypertrophy of the islets, at least after thyroidectomy

2 Excessive administration of epinephrin, thyroid extract, and possibly hypophyseal extract, may induce temporary hyperglycemia and glycosuria due to increased sugar mobilization But there is no evidence that this glycosuria is, or passes into, true diabetes, that is lowered power to burn sugar, in the absence of a direct pancreas depression This applies also to disturbances of the nervous system.

3 The precise influence of the hypo-activity or hyperactivity of the adrenals, thyroid and hypophysis on the islets of the pancreas cannot at present be definitely stated but it is obvious that organs which are as necessary to life, that is, to healthy normal life, as the parathyroids, the adrenal, the hypophysis, and the thyroid will affect the vital processes of the islet tissue, at least indirectly, through the general disturbance of metabolism and the circulation

After a careful experimental and critical review of the entire question, Allen states that the "polyglandular equilibrium doctrine of diabetes has consisted from the first of ingenious but unfounded speculations" We are in entire accord with this conclusion

The attempt of Pfluger to show that diabetes is due not to hypofunction or loss of the pancreas, but to interference of nervous reflexes from the pancreas to the duodenum and the liver has already been referred to. Any general reflex theory of diabetes is untenable in view of the fact *that every organ so far investigated continues to oxidize sugar after complete denervation* The loss of the sugar oxidizing capacity is, therefore, a hormone, not a reflex phenomenon But the building up of glycogen, especially by the liver, appears to be partly under nervous control

Other workers have pointed to the probable importance, direct and indirect, of the gastro intestinal tract in diabetes Case has recently reported a striking parallel between the severity of clinical diabetes and the degree of ileal stasis If the ileal stasis is a primary factor this would point to intestinal intoxication depressing the pancreas as a contributory factor in diabetes

The administration of sodium carbonate reduces temporarily the glycosuria of depancreatized dogs This fact has led Murlin to suggest

that the diabetes following extirpation of the pancreas may be due in part, to the unneutralized HCL of the stomach secretion Murlin and Sweet have removed the stomach in depancreatized dogs and find that the glycosuria is less severe than with the stomach intact But such animals are probably more depressed than after pancreatectomy alone, and the low output of sugar may be due to this condition

Summary

1 All the evidence supports the view that some substance or hormone secreted by the islands of Langerhans into the blood is necessary for the building up of glycogen and oxidation of sugar by the tissues This function is specific for the pancreas Other endocrine organs (adrenals thyroid) may influence sugar metabolism in a superficial way by altering the sugar mobilization, or by increasing or decreasing the rate of oxidation in the body in general The rest of the endocrine glands cannot maintain the power of the tissues to oxidize sugar in the absence of the pancreas, and the hypo activity or hyperactivity of other endocrine glands does not produce diabetes in the presence of a normal pancreas

2 While the failure of the tissues to burn sugar in the absence of the pancreas is the central and definitely established fact there are probably other primary defects and equally important impairments involved in the development of acidosis increased metabolism lowered resistance infection lipemia etc

3 All the evidence points to the view that true diabetes mellitus in man is primarily the result of pancreatic (islets) deficiency, or inhibition of the *islet hormones on the tissues*

4 The insulin of Banting Best Collip and Macleod may prove to be a specific and useful substance in the control of diabetes But so far as the evidence now stands it is not a cure and the dietary control of diabetes as developed especially by Allen Newburg and others will probably always constitute a necessary factor in the therapy of diabetes

5 There is no evidence that the various pancreas extract preparations on the market, advertised as active when given by mouth are of any value in diabetes

THE SUPRARENAL GLANDS

Anatomy—The suprarenal glands of man and the higher animals consist of at least two distinct tissues The cortex is of mesodermal origin and belongs to a system known as the *interrenal system*. The medulla is of ectodermal origin starting as a part of the sympathetic nervous tissues It is a part of the 'adrenal or 'chromaffine system (so called

tissues to store and oxidize sugar that true diabetes follows A critical analysis of the entire literature, experimental and clinical, seems to warrant the following conclusions

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aqua) it is present in part of the skin and the skin secretion of this animal is reported to contain epinephrin (Abel)

The suprarenal gland has a very rich blood supply According to Neumann the blood supply to these glands is greater than to any other organ in the body, or 6 to 7 c c per gram of gland per minute This enormous blood supply is undoubtedly of significance in relation to the secretory and possibly, detoxicating functions of the gland

Each adrenal gland receives numerous nerve filaments from the splanchnic nerves and the adrenal plexus The nerve filaments are distributed both to the cortex and the medulla part of the fibers passes to the blood vessels (vasomotor nerves) and part appears to end around the gland cells (secretory nerves?) True sympathetic nerve cells are also found both in the cortex and in the medulla Nothing is known concerning sensory nerve supply to the adrenals

Chemistry of Medullary Tissue —Oliver and Schafer showed that extracts of the medulla of the suprarenal glands when injected intravenously, caused a marked rise of blood pressure

The chemical work of Abel, von Furth Takamine Aldrich Dakin Stolz, Flacher and others resulted in the isolation of and later synthesis (from coal tar derivatives) of a definite chemical compound named by Abel *epinephrin* by Takamine *adrenalin* Chemically this compound is dioxyphenylethylolmethylamin ($C_9H_{13}NO_3$) It is levorotatory The compound made synthetically is optically inactive and has only about one half of the physiological activity of the natural compound (Cushny Schultz) It can, however be separated into two optically active isomers one of which, the levorotatory compound seems identical in every respect with the natural base Epinephrin is present in all chromaphile tissues (Vincent, Fulk and Macleod) It appears very early in the fetal adrenals at least in most species (McCord Fenger Cevolatto Langlois and Rehns) But Lewis failed to detect epinephrin in the fetal adrenals in man This is important in view of the fact that there is no evidence of adrenal insufficiency in prematurely born infants If epinephrin is absent in the human fetus in late gestation (seven to eight months), this substance is evidently not necessary for life

It is estimated that the normal adrenals of adult persons contain at any one time only a few milligrams (6 to 9) of epinephrin (Elliott) The adrenals of normal dogs contain 1 to 2 milligrams of epinephrin (Sydenstricker) Trendelenburg reported that the adrenals of the cat secrete into the blood about 0 00 milligram of epinephrin per minute or about 5 milligrams per kilo body weight in twenty four hours Hoskins and McClure estimated the output of epinephrin in the dog as 0 2 c c of a 1 1 000,000 dilution of epinephrin per minute per kilo body weight The same authors found that the blood of the general circulation (dog) contains epinephrin in the concentration of 1 200 000 000 Trendelen

from its affinity for the salts of chromic acid) A very considerable amount of chromaffine tissue is found in man outside of the suprarenals (in small masses along the sympathetic nerves and in the carotid gland) interrenal tissue is also often found in other parts of the body outside of the suprarenals

These two parts are anatomically separated in some fishes, but in man and the higher animals they are so intimately connected that it is very difficult to study their functions separately, and most of the knowledge on this subject is based upon observations and experiments upon the entire organ Accessory suprarenals (medullary tissue, or cortical tissue, or both combined) occur in some animals, particularly the rat

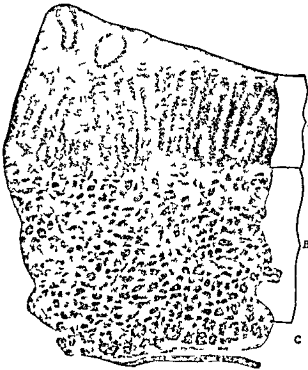

FIG 9—SECTION OF SUPRARENAL OF CHILD TWELVE DAYS OLD LOW POWER A outer part of cortex B large cells forming boundary zone of cortex C thin layer of medulla just below is the central vein (Elliott and Armour)

The cortex is made up of polygonal epithelium like cells arranged in columns and rich in a double refractive lipoid substance In the pig this lipoid makes up 38 8 per cent of the dry cortical residue (Biedl)

The fetal adrenals are relatively large, at one stage the cortex extending throughout the whole length of the body cavity The female rat has a larger adrenal gland than the male In other species such sex differences have not been made out but there appears to be some hypertrophy of the adrenal cortex associated with the periods of rut and pregnancy In man there occur certain degenerative changes that lead to diminution of the adrenal cortex during the first two weeks after birth (Lewis and Pappenheimer) The modified nerve cells of the medullary portion are characterized by their brown color reaction with chromic acid (chromaphile reaction) This chromaphile tissue has been found in certain parts of the nervous system and in the skin of various invertebrates In the American toad (Bufo

2 The quantity of epinephrin in the blood sufficient to raise the blood pressure or to affect the blood pressure is more than sufficient to inhibit the motility of the gastro intestinal tract In fact the gastro intestinal tract is more sensitive to the inhibitory action of epinephrin than the heart and the blood vessels to its tonic or stimulation action *Hence as long as gastro intestinal motility is present there is not enough epinephrin in the blood to influence the tone of the heart and the blood vessels*

3 Complete or practically complete suppression of epinephrin secretion by section of the adrenal nerves does not induce lowering of the blood pressure or impairment of the heart

4 The minimum effective dose of epinephrin causes a *fall* not a rise of blood pressure

Emergency Theory of Adrenal Function—This theory was proposed by Cannon in 1914, based partly on data already in the literature partly on work by Cannon and his associates This theory assumes that under conditions of marked physiological stress such as pain anger fear other intense emotions, asphyxia, etc , there is a sufficiently increased secretion of epinephrin to have physiological and useful action for the survival of the animal In support of this theory Cannon musters the following arguments

1 It seems well established that hypodermatic or intravenous injections of suitable quantities of epinephrin stimulate the heart raise the arterial blood pressure increase the coagulability of the blood mobilize the liver glycogen in the form of increased blood sugar increase the resistance to fatigue of the skeletal neuromuscular mechanisms increase the coagulability of the blood, and induce a temporary polycythemia

2 It is also established that direct stimulation of the peripheral end of the splanchnic nerves causes sufficient augmentation of epinephrin output to have demonstrable physiological effects (rise in blood pressure dilation of the pupils etc)

3 That stimulation of the sciatic (pain) asphyxia anger, etc , acts on the epinephrin secretory nervous mechanism in the way of stimulation Cannon and his coworkers Anrep and others, have tried to prove by the behavior of the denervated heart under these conditions before and after adrenalectomy, also by direct essay (intestinal strip) of the epinephrin content of the blood by vasoconstriction in the denervated leg by the reaction of the denervated pupil and by increased secretion in the denervated salivary gland Some of these tests were made without anesthesia, and the reported results indicate that sciatic stimulation (pain) asphyxia and strong emotions cause increased secretion of epinephrin

Stewart and Rogoff have repeated or checked all of these experiments both with the original methods and with improved methods of their own

burg states that the epinephrin content of the carotid blood of the normal rabbit does not exceed *one part to two milliards of blood*. Stewart and Rogoff give the following figures for the average rate of epinephrin secretion (animals under light anesthesia) per kilo body weight of animal: cat, 0.00025 milligram; dog, 0.00022 milligram; monkey, 0.0002 milligram; rabbit, 0.0003 milligram.

Epinephrin is a rather unstable body. It is oxidized or destroyed only slowly in the blood, but rapidly by the tissue and the walls of the blood vessels (Tatum). Hence, giving epinephrin by mouth is practically without physiological effects.

Tonus Theory of Adrenal Function.—It seems well established that *the suprarenal glands under normal conditions secrete epinephrin into the blood of the adrenal veins continuously* and at a remarkably constant rate. It was formerly supposed that enough epinephrin is thus secreted by the normal adrenals to maintain a steady stimulation of, or tonic action on, the

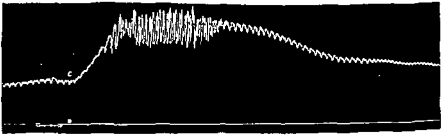

FIG. 10.—EFFECTS OF INTRAVENOUS INJECTION OF ADRENAL EXTRACT (EPINEPHRIN) ON THE HEART AND THE BLOOD-PRESSURE. (Oliver and Schafer.)

heart and the blood vessels, thus aiding in the maintenance of the normal blood pressure. This constituted the so-called *tonus theory of adrenal function*. The work of Cannon, Hoskins, Stewart, and others has rendered this tonus theory untenable, for the following reasons:

1. The quantity of epinephrin secreted into the blood under ordinary conditions is too small to have any appreciable effect on the heart or the blood vessels. Hoskins found that it requires 0.42 c.c. of a 1:1,000,000 epinephrin per kilo body weight per minute to affect the blood pressure in the dog, and *this minimum quantity causes vasodilatation, not vasoconstriction* (Cannon, Hoskins). The normal output of epinephrin by the dog's adrenals is only 0.2 c.c. of this epinephrin concentration per minute. The maximum concentration of epinephrin in the adrenal veins is 1:500,000 (Stewart and Rogoff). Even assuming that there is no *destruction of epinephrin until it reaches the systemic capillaries* the dilution of this substance in the arterial blood will be 1:500,000,000 or 1:1,000,000,000.

normal (Bedford and Jackson) Stewart Rogoff and Gibson found that massage of the suprarenals increases the secretion of epinephrin

Anesthetics including morphin decrease the epinephrin content of the glands (Graham), presumably through a preliminary increased secretion But depression of the rate of building up the secretion in the gland may also be a factor The epinephrin content of the glands is also greatly decreased in many infectious diseases especially the acute infections such as peritonitis (Elliott, Reich, and Berenegowski Kindley and others) But there is no evidence that epinephrin deficiency is a factor in the debility and prostration of acute infections Pellegrini states that the amount of chromaffin tissue is reduced by starvation But Jackson, McCarrison and others have reported hypertrophy of the adrenals in starvation and after vitamin poor diets Thyroid feeding is said to induce adrenal hypertrophy

According to Ott and Scott and Gley and Quinquad extracts of pancreas liver, thyroid, thymus gonads kidneys, pituitary parathyroid etc, cause an increased output of epinephrin Evidently this is a toxic action of protein split products in the tissue extracts acting via the vasomotor center and the splanchnic nerves, and possibly directly on the medullary cells It is of no significance in the relation of these organs to the normal work of the suprarenals

Dale and Elliott have suggested that some of the general systemic actions of alkaloids like nicotin and pilocarpin, and the anesthetics (morphia, chloroform and ether) are indirect effects due to the increased output of epinephrin caused by these substances Strychnin and serin increase the epinephrin output Nicotin decreases the output The reports on pilocarpin are contradictory

There appear to be no seasonal variations in the epinephrin content of the adrenal gland (Seidell and Fenger)

Pharmacological Actions of Epinephrin—Knowledge of the details of the pharmacological action of epinephrin has increased greatly within the last few years and it is now possible to express nearly all the facts in the form of a general law *the peripheral effects of epinephrin are in most cases essentially the same as those of the stimulation of the sympathetic visceral efferent nerves to the tissues involved* The peripheral action is upon the 'myoneural junction which is a part of the 'receptive substance' (Langley) of the cell In sufficient concentration epinephrin acts also on the central nervous system It also acts on peripheral mechanisms in which sympathetic innervation has not yet been demonstrated

The following illustrations show some of the applications of this law

Blood vessels—The very great rise of blood pressure following the intravenous injection of large doses of epinephrin is due largely to a peripheral constriction of the blood vessels especially of those of the

but failed to secure any evidence of reflex (pain), asphyxial or emotional stimulation of the adrenal medulla

The theory has thus far no unchallenged experimental support Even if future work should prove the theory tenable, it must be shown that animals with denervated adrenals are handicapped in their natural environment If that is not the case, the reaction may have no greater biological significance than the blushing that may or may not follow the feeling of embarrassment in some people

Theory of Epinephrin Control of Functions of Blood Capillaries—Extensive studies on dogs, cats and rabbits led Gradinescu to conclude that the suprarenal secretion controls metabolism by controlling the permeability of the blood capillaries, and hence the exchange between the blood *and the tissues He claims that adrenal deficiency causes the blood plasma* to pass into the tissue spaces and the body cavities to such an extent that the concentration of blood-corpuscles becomes twice as great as the normal The viscosity of such blood is obviously great and the circulation correspondingly impeded But it is possible that the transudation of plasma from the blood noted by Gradinescu is in reality an effect from the impaired circulation (cardiac edema) But Donath maintains that change in capillary permeability is a factor This theory should be reinvestigated in the light of the recent work of Krogh and others on the nervous and chemical control of the blood capillaries

Secretion of the Epinephrin—Direct stimulation of the splanchnic nerves increases the output of epinephrin (Biedl, Dreyer, Cannon, Elliott and others) It is generally assumed that this is a true secretory action of the adrenal nerves on the medullary cells But the stimulation of the splanchnics causes at the same time vasodilation of the suprarenals while it is well known that this stimulation induces vasoconstriction in all the other abdominal organs innervated by the splanchnic nerves It is not known whether the increased blood flow through the glands by hormone action increases the epinephrin output We have seen that the view that painful sensory stimuli, intense emotions, and asphyxia increase the output of epinephrin has been denied by Stewart and Rogoff on the basis of a series of careful experiments It would seem that some of the work of Elliott, Cannon, and others, was not adequately *controlled*

Richards and Wood report that stimulation of the depressor nerves leads to a decreased output of epinephrin, they interpret this as a true reflex inhibition of the action of the secretory nerves Pende claims that section of the splanchnic nerves leads eventually to atrophy of the medulla This is probably erroneous

Surgical and traumatic "shock" reduces the epinephrin content of the glands to only a fraction of their normal amounts (Corbett) Shock induced by hemorrhage or manipulation of the viscera increases the epinephrin content of the blood coming from the glands up to thirty times the

on some parts of the gut depends on the state of tonus of that part at the time of application of epinephrin For example if the mammalian cardia is in strong tonus, epinephrin causes inhibition if the cardia is a feeble tonus, epinephrin causes contraction (Carlson)

Urinary Bladder —The same relations hold for the bladder as for the alimentary tract in those animals in which stimulation of the sympathetic causes relaxation of the bladder and contractions of the urethra epinephrin

A

B

C

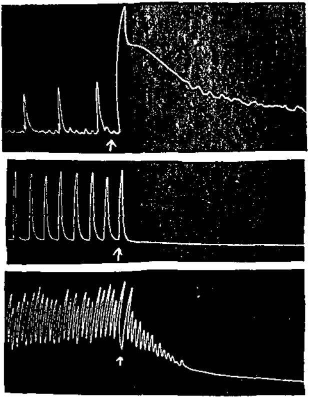

Fig 11 —A Stimulation Effect of Epinephrin on the Rabbit's Uterus (Itagaki)
B Inhibitory Effect of Epinephrin on the Uterus of the Rat (Itagaki)
C Inhibitory Effect of Epinephrin on the Cat's Intestine (Young)

does the same, when stimulation of the sympathetic is without effect upon the bladder, epinephrin is also without effect

Uterus —The effect of the epinephrin upon the uterus is determined by the character of the sympathetic innervation It, like the stimulation of the sympathetic, causes powerful contractions of the pregnant uterus and of the non pregnant uterus in certain animals In the virgin uterus of the cat however both epinephrin and stimulation of the sympathetic cause relaxation Dale was able to demonstrate the presence of a sympa

splanchnic area The constrictor muscles of the blood vessels are innervated by the sympathetic (visceral) nervous system In organs (for example, brain) in which the sympathetic vasoconstrictor innervation is but slightly developed (or, according to some writers, absent) epinephrin has but little (according to some, no) vasoconstricting effect (cf Wiggers)

The minimum effective dose of epinephrin always causes a primary vasodilatation (Cannon, Hoskins) This appears to be, at least in part, a central action, that is, stimulation of the central vasodilator mechanism or inhibition of the constrictor mechanism (Hartman) All strengths of epinephrin appear to cause dilatation of the arteries in the skeletal muscles This action of epinephrin on the blood capillaries is essentially the same (both dilation and constriction) as on the arteries, but some capillaries are refractive to epinephrin, despite their sympathetic innervation (Krogh)

The vasoconstricting action of the drug is seen when it is applied to a *mucous membrane or to the abraded and bleeding skin, the structures be*come blanched and hemorrhages from small vessels cease

Heart —Extracts of suprarenal and epinephrin cause a marked acceleration and strengthening of the heart beat, the effects are the same as those of the stimulation of the accelerators (sympathetic motor nerves) The maximum rate reached is the same as the maximum rate after stimulation of the accelerators, this rate may be maintained for some time by the repeated injections of small doses (Hunt)

In the intact animal the acceleration of the heart is frequently (almost always, if the dose is large) prevented, at least at first, by a simultaneous stimulation of the vagus centers, the latter is attributed in part to the high blood pressure, but there is some direct action of the epinephrin both on the vagi centers and on the respiratory centers (Brown, Nice and Rock)

The Coronary Circulation —Epinephrin contracts the coronary vessels in man and the monkey, but in other mammals (dog cat rabbit, ox, sheep, pig) it dilates the coronary vessels (Barbour and Prince) These dif*ferences are* probably due to the character of the sympathetic innervation of the coronary vessels

Alimentary Tract —The effect of epinephrin on the alimentary tract is on the whole the same as that of the sympathetic nerves When the latter cause inhibition epinephrin does also, when the stimulation of the sympathetic causes contraction epinephrin does the same Thus in the rabbit, epinephrin causes relaxation of the entire alimentary tract with the exception of the pyloric, ileocecal and internal anal sphincters which contract under its influence The action of the sympathetic nerves on the alimentary *tract varies in different species of animals the effects of* epinephrin vary in a corresponding manner

But the primary action (be it stimulation or inhibition) of epinephrin

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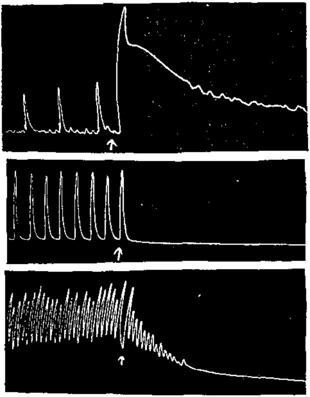

FIG 11—A STIMULATION EFFECT OF EPINEPHRIN ON THE RABBIT'S UTERUS (Itagaki)
B INHIBITORY EFFECT OF EPINEPHRIN ON THE UTERUS OF THE RAT (Itagaki)
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But the primary action (be it stimulation or inhibition) of epinephrin

activity But it is difficult to see how this is possible on the basis of the relation of the adrenal veins to the kidney arteries And in the general arterial blood there is not enough epinephrin present to act on the renal arteries

Metabolism—Epinephrin has little effect upon nitrogen metabolism except in inanition, when it is said to increase protein metabolism This effect is attributed by Eppinger, Falta and Rudinger to a stimulation action upon the thyroid Recent work by Boothby seems to show that epinephrin increases temporarily the basal metabolic rate Cannon has reported that intravenous injections of epinephrin induce temporary electrical changes in the thyroid gland, which he interprets as due to increased thyroid activity But there is no antagonistic action of the thyroid glands to epinephrin glycosuria as determined by the reaction of the animal after extirpation of these glands (Blum and Mark) Wolfe and Thatcher found the nitrogen metabolism normal in a case of Addison's disease The endogenous metabolism as represented by creatinin and uric acid, was below normal

Epinephrin has a marked effect upon the glycogen sugar mobilization in the body This appears to be due to the stimulation of certain sympathetic nerves (Tatum) The epinephrin glycosuria is accompanied and caused by a hyperglycemia and a diminution of or disappearance of glycogen from liver and muscle *The degree of glycosuria is largely determined* by the amount of glycogen in the liver, although some excretion of sugar is caused in starving animals

Zuelzer Embden and others have found that when epinephrin is added to blood used in perfusing an excised liver, it causes the latter to liberate sugar into the hepatic vein in far greater amounts than when normal blood is used The above facts lead to the conclusion that the action of epinephrin in producing glycosuria is due to a setting free or mobilization of the sugar stored as glycogen

It must be noted however, that the above effects of large doses of epinephrin intravenously on glycogenolysis are strictly speaking artefacts There is no evidence that such amounts of epinephrin are under any conditions put into the blood by the glands in the intact animal The specific antagonistic action of the suprarenal and the pancreatic secretions on sugar metabolism advanced by Falta and others has proved to be erroneous (Mann and Drips) Epinephrin administration does not affect the oxidation *of the sugar in the body* (Lusk) Epinephrin deficiency causes no permanent change in carbohydrate tolerance (Crowe and Wislocki) The failure of pancreas extirpation to cause diabetes after previous adrenalectomy in some species is due to the low blood pressure and the moribund condition of the animal (McGuigan)

Epinephrin in certain concentrations (intravenously) increases the coagulability of the blood (Cannon and Mendenhall) In larger doses the

thetic inhibitory supply to the uterus of other animals also After very large doses of ergot, which paralyze the motor nerves, stimulation of the sympathetic or the administration of epinephrin causes relaxation of the uterus in all cases The conditions are analogous to those which hold for certain blood vessels

The action of epinephrin upon the uterus is one of the most delicate tests for the drug (Frankel's test), a solution containing one part in twenty millions is active

Bronchial Muscles—The effect of the epinephrin upon the bronchial muscles is of special interest, since it appears that attacks of bronchial asthma in man are temporarily relieved by it. This suggests the presence of sympathetic inhibitory nerves to the bronchial muscles, but attempts to demonstrate their existence have been unsuccessful Similarly, efforts to demonstrate an action of epinephrin upon the bronchial muscles have usually failed Eppinger and Hess, however, believe that epinephrin may, through the stimulation of sympathetic inhibitory nerves, counter act the contractions of the bronchial muscles caused by increased vagus tonus Januschke and Pollak found that it relaxed the bronchial muscles in muscarin asthma and had some relaxing effect on normal animals In frogs and salamanders epinephrin inhibits the hypertonic lung mus culature by peripheral action In turtles and snakes the central lung motor mechanism is inhibited by small doses, larger doses depress the lung musculature by peripheral action (Carlson and Luckhardt)

Action on the Pupil—The intravenous injection of epinephrin into animals causes the same changes in the eye as follow the stimulation of the cervical sympathetic nerve, namely, retraction of the nictitating membrane and of the eyelids, protrusion of the eyeball, and dilatation of the pupil (through stimulation of the dilator muscle) Instillation of epinephrin into the eye is far more effective in causing dilatation of the pupil when the superior cervical ganglion has been extirpated than it is in normal animals (Meltzer and Auer), this reaction has been utilized in *locating the site of injuries to the cervical sympathetic* (Cords, Sebileau, and Lamaitre) Solutions of epinephrin applied repeatedly to the nor mal human eye cause dilatation of the pupil (Schultz and Wessley) Slight lesions of the cornea greatly facilitate the reactions, Cords has used the reaction to detect erosions and ulcers of the cornea

The pupil of the frog's eye (either *in situ* or enucleated) dilates upon the application of very minute amounts of epinephrin Meltzer and Auer suggested that this reaction might be used for the detection and estima tion of this substance The reaction was elaborated by Ehrmann as a test for epinephrin

The Kidneys—According to Cow, epinephrin passes directly into the blood of the renal arteries and by its local vasoconstrictor action diminishes the rate of urine secretion, thus acting *as an important control of kidney*

are extirpated in one operation Elliott reports that complete extirpation of the adrenals in the cat leads to death with low blood pressure fall of temperature and great depression of vasomotor and cardiac accelerator nerves But Hoskins and Wheelon state the vasomotor system and the vasomusculature are unimpaired at a time when marked asthenia of cardiac and skeletal muscles is in evidence Hence there is no evidence that the sympathetic system suffers *primarily* in any degree from adrenal extirpation In cats adrenalectomy reduces the basal metabolism about 25 per cent (Aub) This reduction sets in within a few hours after the operation But non lethal injuries (ligation freezing) are said to induce a definite but temporarily increased heat production and this does not occur if the thyroids are removed previous to the adrenal injury (Marine and Baumann, Scott)

Injections of epinephrin do not increase vasomotor irritability (Hoskins and Rowley) Complete ligation of the adrenal blood vessels leads in a few hours to a distinct fall of blood pressure, but this is no evidence that this fall is due to lack of epinephrin according to McGuigan and Mostrom

Pierry and Malloisel and also Porges have reported a condition of hypoglycemia after adrenalectomy But this is probably not specific for any condition that induces a marked general depression is accompanied by hypoglycemia (McGuigan) Porges found hypoglycemia in three cases of Addison s disease The reduced amount of sugar in the blood has been held to explain, in part the most striking symptom following the removal of the suprarenals—*the asthenia* Favorable results in Addison s disease are reported from the administration of sugar (Pitres and Gautrelet) Animals deprived of their suprarenals are easily fatigued If forced to exercise they may die suddenly But that would probably be true of animals equally moribund from other causes

Crowe and Wislocki report enlargement of the lymph glands in adrenal insufficiency Loewi and Geltwert state that the blood of cold blooded animals from which the adrenals have been removed is toxic. When applied to the heart the heart stops in diastole, evidently by vagus stimulation as the toxic action is abolished by atropin Whipple and Christman state that adrenal deficiency leads to impairment of the liver as determined by the phenolphthalein test This is probably an indirect effect of impairment of the circulation

The questions as to which part of the suprarenal system the interrenal (cortical) or the adrenal (medullary), or both are essential to life, has been much debated some authors have considered that only the former others that only the latter is essential to life All the evidence points to the cortex as the essential part but if there is any truth in Gradinescu s theory of epinephrin control of capillary permeability, it is evident that the medulla is of some importance

coagulation is delayed According to Cannon, adrenalin also acts as a stimulant to the skeletal neuromuscular mechanism, and he interprets this as due to a direct action of epinephrin on the muscle, but this has recently been questioned by Schafer The improved circulation and the mobilization of the blood sugar may be the factor in delaying fatigue after large epinephrin injections Epinephrin induces vasodilatation in the skeletal muscles (Hoskins, Gunning, Berry)

Functions of the Adrenal Cortex—Concerning the role of the adrenal cortex we have a number of theories, but very few facts No internal secretion has so far been demonstrated Whipple has obtained an extract from the cortex having a pituitrinlike action on the circulation The abundance of lipoids in the cortical cells has led to the suggestion that the cortex elaborates these for the use of distant organs It has also been supposed, without evidence, that the precursors of epinephrin are elaborated in the cortex In the absence of a definite internal secretion of the cortex, theories of detoxicating functions have been advanced

Cortex Essential to Life— All the evidence, experimental and clinical, to date, points to the cortex rather than the medulla as the organ essential to life (Biedl, Scott and others) In nearly complete adrenalectomy only the cortical remnants undergo hypertrophy (Crowe and Wislocki)

The most striking correlation of the adrenal cortex appears to be with the gonads Estrus (male and female), pregnancy, lactation, and gonadectomy are in some species accompanied by increase in cortical substance Tumors and hyperplasias (hypernephroma) of the cortex may be accompanied by precocious sex developments (secondary sex characters) both in the male and the female (Jump, Beates and Babcock, Baldwin and others) But these relations are not of a direct and compensatory character For the adrenals fail to maintain sex life after gonadectomy, and the gonads fail to maintain life itself after adrenalectomy

Extirpation of the Suprarenals—The removal or destruction of both suprarenals leads to death within a few hours or days (Brown Sequard), exceptions to this rule are due to the presence of accessory glands Biedl describes the effects as follows for one or two days the animals seem to be entirely normal, on the second or third day there is loss of appetite, afterward apathy and muscular weakness become apparent, the movements become stiff and uncertain Then great prostration follows, the animal is unable to rise, and lies extended on its abdomen There is a marked fall of temperature (to 30° C or under), respiration is labored, the heart is irregular and weak the animal usually dies (in one to three days) in this condition of paralysis Occasionally there are muscular twitchings, more rarely convulsions Gradinescu states that after complete adrenalectomy rabbits die within seven hours, dogs in ten and cats within forty five hours Removal of one adrenal has no effect On removal of the second adrenal the animal usually lives longer than when both glands

adrenia betrays a profound ignorance of modern suprarenal physiology, and a remarkable cavalier attitude toward the canons of logic (Cohoe)

Many attempts have been made to correlate certain conditions of high blood pressure with hypertrophy of the suprarenals especially of the medulla, but it is not certain that the suprarenal changes are primary nor has it been shown that there is an excess of epinephrin in the blood (Stewart)

Control of Experimental Adrenal Deficiency—Efforts to overcome the effects of the removal of the suprarenals in animals have been made both by the administration of the gland and its extracts Neither has so far met with success In no case has life been prolonged for more than a few hours after the administration of the gland to animals from whom the suprarenals have been removed Considerable improvement in the symptoms (increase of blood pressure improved respiration) has frequently been reported from the subcutaneous or intravenous injection of extracts of the gland but the results did not differ from those observed in animals near death from poisons and other causes Feeding adrenal tissue, fresh or dried may be a failure due to the destruction of the hypothetical cortical hormone in the gut The only avenue of hope in this field seems to be in fractionation of the adrenal cortex for hypodermic administration

So far, transplantation of the suprarenals has been successful only as a preventive measure, that is it is possible to prevent the characteristic effects of the removal of the glands by the previous transplantation of a gland (Bush) Apparently, when the effects of the removal of the glands have become manifest it is not possible to delay death by the transplantation of the glands of other animals Hoskins reports that rats fed on dried adrenal glands for two to nine weeks showed hypertrophy of ovaries and testes, but no change in other organs in growth or in general condition

Organotherapeutics in Suprarenal Deficiency in Man—*Addison s Disease*—Addison s disease is the only condition in man in which a suprarenal insufficiency clearly exists and most of the interest in the organotherapeutic use of the suprarenals centers around it *The results are essentially negative*

Other Conditions of Supposed Suprarenal Insufficiency—Suprarenal glands and epinephrin have been administered in a number of conditions in which an insufficiency of the glands had upon inconclusive evidence, been supposed to be present The results have been inconclusive

It has been supposed for example, that a condition of suprarenal insufficiency exists in many chronic diseases especially tuberculosis and the administration of the gland, or of epinephrin recommended accordingly It has also been recommended in neurasthenia associated with low blood pressure It has found extensive use in the cardiovascular exhaustion of acute infectious diseases In this condition, however it is used as are

Disease of the Suprarenal Glands—The first important contribution to the knowledge of the function of the suprarenals was the classical paper of Addison (1855) on the disease which bears his name The disease is characterized by a condition of muscular and cardiac weakness, usually with a low blood pressure, a subnormal temperature, apathy, disturbances of the digestive tract (vomiting, diarrhea or constipation finally asthenia), pigmentation of the skin and mucous membranes, and a progressive cachexia almost always ending in death There may be periods of spontaneous but temporary improvement *Tieken reports a case of apparently permanent (two years) recovery from Addison's disease* All the features of adrenal disease in man are reproduced by adrenal extirpation *in animals except the skin pigmentation This may be due to the speedy* fatality of complete adrenalectomy, it evidently requires more time for effecting the change in skin pigmentation

The typical anatomical change found in the suprarenals in Addison's disease is a tuberculous degeneration The chromaffine tissue in connection with the sympathetic nerves, outside of the suprarenal glands, has also been found involved in a number of cases, in others the chromaffine tissue both in and outside of the suprarenal glands was apparently intact It is practically certain that Addison's disease is due to impairment of the adrenal cortex

Absence of epinephrin has been found in a number of cases of Addison's disease (Oliver and Schafer, Luksch, Ingler and Schmorl)

Studies of other abnormal conditions of the suprarenal glands in man have only been suggestive of possible functions of these organs It has long been known that in many cases of congenital malformations (anencephalia, hydrocephalus) the suprarenals show a condition of hypoplasia or of aplasia In some of these cases only the medulla was involved, the cortex being normal The relations of these conditions whether casual or not, have not been definitely determined On the other hand, excessive growth has been reported in cases of tumors of the suprarenals

Hypoplasia of the suprarenals has been met in a few cases of retarded sexual development, and in cases of osteomalacia and status lymphaticus On the other hand, hypernephromas originating from cortical suprarenal tissue have, in a number of cases, in infants and young children, been associated with sex precocity, and in the case of girls with development of male characters—such as masculine hair on the face

Hypo adrenia and Hyperadrenia—During the last twenty years an increasing number of disease symptoms (depression, asthenias, etc) has been referred to a diminished output of epinephrin This chapter in medicine is a serious reflection on the knowledge and common sense of the medical profession There is no evidence that hypo adrenia (too little epinephrin) exists except after denervation of the adrenals, or that if it does exist it could produce disease (Stewart) 'The literature on hypo

an effect when given subcutaneously as when given intravenously. Intramuscular injections are much more efficacious than subcutaneous ones.

Epinephrin also differs from most alkaloids (Straub) in that it does not accumulate in the tissues and that it is quickly destroyed in the body; it exerts its action only during its passage into the tissues and, hence, its action depends upon the difference in the concentration in the tissues and in the concentration in the blood rather than upon its absolute amount. Moreover, its effect does not become less after repeated administration; the hundredth injection, for example, causes as great a rise of blood pressure as does the first and subsequent injections.

The above considerations indicate that the best results when the drug is used as a cardiovascular stimulant are to be expected from the continuous infusion of a weak solution. This conclusion coincides with clinical experience. Although life has undoubtedly been temporarily saved by intramuscular or intravenous injections of comparatively strong solutions (4 minims of the 1:1,000 solution, for example), the best results have been obtained by the continuous injection of a solution of 1:50,000 or 1:100,000 in normal saline solution.

Epinephrin is quickly absorbed from the lungs, and Auer and Gates suggest its administration by intratracheal sufflation in cases calling for a sudden stimulation of the heart.

The use of this drug as a cardiovascular stimulant has proved useful in conditions of cardiac and vasomotor failure under anesthesia (general and spinal), in shock and acute hemorrhage, and in cases of poisoning (as by chloroform and chloral), although very favorable results have also been reported in the low blood pressure of pneumonia and other acute infectious diseases—especially of children. In diphtheria it is said to relieve prostration and asthenia aside from its effect on blood pressure. Rolleston administered it by the mouth in 10 minim doses of the 1:1,000 solution every two to four hours, according to the severity of the attack.

Laewen and Sievers state that in certain conditions of stoppage of the heart the injection of 0.2 c.c. of the 1:1,000 solution directly into the heart is permissible.

The greatest field of usefulness of epinephrin, however, is as a *local hemostatic*.

It is used to check epistaxis and also hemorrhages into the rectum (hemorrhoids), bladder (100 c.c. of the 1:10,000 solution, for example), uterus, etc., and to relieve congestion of the conjunctiva and of the mucous membrane of the nose (as in rhinitis and hay fever) and of other organs.

It has been used in postpartum hemorrhage; it not only constricts the blood vessels, but causes a contraction of the muscle fibers of the uterus.

It may be applied in solutions of from 1:1,000 or 1:20,000 either directly or on cotton, or as a spray, or in ointments. Cavities, such as those

other cardiovascular tonics, that is, it is used as are other drugs, and not as an organotherapeutic agent in the usual meaning of the term

The suprarenal gland, and especially epinephrin, has been used extensively in osteomalacia The views as to the value of this mode of treatment (proposed by Bossi) are conflicting, some report favorable results Novak for example reports seven cases treated by subcutaneous injections of 0 5 to 1 c c of the 1 1,000 solution Three were improved, in two there was a slight diminution of the bone pains at the beginning, and in two there was no effect.

Attempts to deduce a rational basis for the use of suprarenal in osteomalacia have been made from the following facts There may be some antagonistic (or supplementary) relation between the ovaries and the suprarenals *the latter hypertrophy when the former are removed or are atrophic*, and also in pregnancy when parts of the ovary are physiologically quiescent Christofoletti has advanced the hypothesis that in osteomalacia there is a hypofunctioning of the chromaffine tissue due to a hypofunctioning of the ovaries As was pointed out above, however, in discussing the relation between suprarenals and the sex glands the cortex seems to be the part of the former which is chiefly involved, whereas, in the treatment of osteomalacia, a product of the medulla (epinephrin) is usually employed The favorable results which at times seem to follow the use of epinephrin *in osteomalacia are probably due to other factors*

Certain writers have drawn analogies between the skin pigmentation the lassitude and the vomiting of pregnancy, and some of the symptoms of Addison s disease, and have treated some cases of vomiting of pregnancy by the administration, *per os* or subcutaneously, of 10 drops of the 1 1,000 solution of epinephrin Distinct benefit has been reported from such treatment

Adrenal preparations have been used in cases of gastro intestinal atony, in diabetes insipidus, rickets, neurasthenia, myasthenia, and other conditions *where there is no evidence of primary adrenal insufficiency*

Pharmacological Uses—The suprarenal glands (epinephrin, adrenalin) are extensively used as a cardiovascular stimulant as a local hemostatic to delay absorption of local anesthetics and to relieve asthma *Solutions of the active principle (epinephrin or adrenalin) have replaced* the crude extracts of the glands for this purpose The use of the drug in these cases does not differ from that of other pharmacodynamic agents, and its detailed consideration does not properly belong in a chapter on Organotherapeutics The action of the alkaloid epinephrin, has, however, *certain* peculiarities which may properly be pointed out in this connection When applied locally it causes an intense constriction of blood vessels, and this action largely prevents its absorption, hence, when given by the mouth or subcutaneously it produces systemic effects only after very large doses One hundred times as much is said to be required to produce

names are proprietary It seems better to use the word epinephrin, proposed by Abel, to designate the active principle

Untoward Effects of Epinephrin—Considering the extent to which the drug is used, accidents are very rare A few deaths have been reported from the injection of the 1 1 000 solution into veins or into the uterus One milligram injected into a vein has caused alarming symptoms, 0 3 milligram injected into the uterine cavity has caused collapse for one-half hour

The intravenous injection of epinephrin is contra indicated in organic heart lesions, nephritis, and arteriosclerosis

A number of cases of necrosis and gangrene of the skin have been reported following the subcutaneous injection these occurred for the most part in the aged Necrosis of the jaw has also been reported

Severe hemorrhage following its local application has been described, this is attributed to the use of too strong solutions which constrict larger vessels, so that the surgeon neglects to tie them

Its repeated administration in large doses to animals is said to cause sclerotic changes in the arteries The fact has been disputed, if correct, the sclerosis is probably due to the high blood pressure Very large doses intravenously are fatal the symptoms being a primary excitation and subsequent depression and failure of the central nervous system Post mortem findings are visceral hemorrhages or pulmonary edema (Vincent)

SUMMARY

1 Complete destruction or loss of the adrenal glands is rapidly fatal, but why this leads to death is still unknown The adrenal cortex is the part of the organ essential to life

2 The adrenal medulla secretes a substance, epinephrin into the blood In sufficient concentrations this substance has specific and striking pharmacological actions on the vascular system the nervous system sugar mobilization, the blood and the alimentary canal But the quantity secreted under normal conditions is not sufficient to produce any of these effects, with the possible exception of a slight action on the heart and some action on the blood capillaries in the nature of controlling their permeability or secretory activity Whether in conditions of emotional stress pain and intense muscular and nervous activity there is enough epinephrin secreted, by secretory nerve action or through change in the blood flow, to have distinct physiological effects—the emergency function of the medulla—is still an open question The medullary secretion has been isolated chemically (epinephrin) and shown to be a useful drug in many conditions (circulatory depression hemorrhage asthma etc) not related to any hypofunction of the gland Epinephrin is probably a waste product or an excretion rather than a hormone

of the nose and uterus, may be packed with gauze wet with a 1:5,000 or 1:10,000 solution.

It has also been administered by the mouth (10 to 20 drops of the 1:1,000 solution), and also subcutaneously in gastric and intestinal hemorrhages (as in typhoid fever), although some report but little benefit from such use. The value of epinephrin in controlling internal hemorrhages is doubtful in all cases except where the drug can be applied directly to the bleeding surface.

Epinephrin has been extensively used to enhance the action of local anesthetics, such as cocain, novocain, etc. It exerts this action not only by delaying the absorption of the anesthetic (by which the danger of systemic intoxication is also lessened), but, in the case of some of the drugs of this class, it seems to have a direct effect upon the action of the anesthetic itself (Esch). On the other hand, it is stated (Frohlich and Loewi) that cocain increases the sensitiveness of various organs (blood vessels, urinary bladder, eye) to epinephrin (and to direct stimulation of the sympathetic nerves), so that a weaker solution of epinephrin suffices to cause constriction of vessels when combined with cocain. Such combinations of epinephrin and cocain are useful, not only in cases of operation, but in examinations.

A few drops of epinephrin solution, 1:1,000, are frequently added to Schleich's solutions for local anesthesia; it is also used in connection with the induction of spinal anesthesia.

Epinephrin has been much used to relieve the attacks of *bronchial asthma*; it is applied locally as a spray (epinephrin 1 part, water 750 parts, glycerin 250 parts (Zuelzer), aqueous solution, 1:1,000 or 1:4,000), or as an ointment (30 to 60 drops of the 1:1,000 solution in adeps lanæ hydrosus and petrolatum, 1 dram each), by subcutaneous injection, or by rectal suppository (Matthews).

Preparation and Dosage of Epinephrin.—At present the drug is employed almost exclusively in the form of solutions of one of the salts, usually the chlorid of epinephrin. The solutions on the market are usually 1:1,000 in normal saline solution; they usually contain a preservative. They deteriorate rather rapidly on exposure to air and light, becoming first reddish and then brown; slightly reddish solutions may be used, but the brown ones should not be used. Many of the commercial solutions as found on the market vary greatly in strength (Schultz); this may be due to deterioration through age, or the solutions may not have been made of proper strength originally. They should be physiologically standardized, unless a very pure preparation of the active principle is used.

The active principle of the medulla is known by a great variety of names: adrenalin, adrenin, adrin, suprarenalin, supracapsulin, hemisin, suprarenin (both natural and synthetic), epirenin, etc. Most of these

distinct and separate lines of function or only different physiological states of one type of function is still an open question The chromophile cells contain what appears to be true secretion granules, and they are usually most abundant in the region of the cell adjacent to the lymph spaces and the blood capillaries

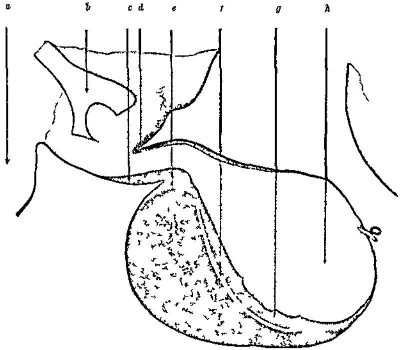

FIG 12—MESIAL SAGITTAL SECTION THROUGH THE PITUITARY BODY OF AN ADULT MONKEY (SEMIDIAGRAMMATIC) *a* optic chiasma *b* third ventricle (infundibulum) *c d* extension of pars intermedia round neck of pituitary *e* pars anterior seu glandularis *f* intraglandular cleft *g* pars intermedia *h* pars nervosa (Herring)

The hypophysis thus resembles the adrenal glands in origin The physiological significance of this juxtaposition or fusion of nervous and epithelial structures into one gland remains unknown Gaskell has advanced the theory that the hypophysis represents the vestigial remnant of the esophagus of our vertebrate ancestors in whom the alimentary tract is supposed to have been placed dorsal to the spinal cord But the effects following disease or removal of the hypophysis seem to show that it is not vestigial in function whatever be the significance of its peculiar origin and composition

The histological picture of the hypophysis, especially the anterior lobe

3 The only malady in man so far definitely shown to be due to adrenal hypofunction is Addison's disease Many other conditions, such as acute infections, various cachexias, prolonged anesthesia, shock, etc, may lead to a decrease in the epinephrin content of the medulla, but there is no evidence that this is an important factor in these complications Tumors of the adrenal cortex (hyperfunction?) may be associated with sexual precocity, and there are other indications of interrelation of some of the specific adrenal and specific gonad functions, but this interrelation is not of a compensatory nature, for none of the functions of the gonads can be assumed by the adrenals, or vice versa

4 *Adrenal therapy fresh gland or extracts by mouth or injections have so far failed to maintain the life of adrenalectomized animals And it has proved itself of uncertain or no value in Addison s disease* In view of these facts no credence can be given to the reports of good results from adrenal therapy in disorders (neurasthenia, disorders of pregnancy, etc) where adrenal hypofunction has not even been established *Adrenal organotherapy is therefore still in the experimental stage*

5 In view of the fact that the adrenal medulla and its secretion (epinephrin) is the part least essential to life, *experimental and empirical organotherapy of Addison s disease should be made with the cortical portion prepared for safe hypodermic injection It can be considered settled that adrenal feeding is a failure*

THE HYPOPHYSIS

Structure of the Hypophysis—The hypophysis is a very complex organ as to structure and possibly in function The anterior lobe (the *glandula pituitaria* proper) develops from a diverticulum of the pharyngeal epithelium and is, therefore, of ectodermal origin The posterior lobe (*pars nervosa* or true hypophysis) is a diverticulum from the neural tube (floor of the third ventricle) In the adult this lobe appears to consist of neuroglial cells together with a few nerve cells, and, in some species, of cells and colloid derived from the pars intermedia The *pars intermedia* is made up of modified lobe cells in intermediate contact with the posterior lobe In some animals these pars intermedia cells penetrate for some dis stance into the posterior lobe

The anterior lobe, true to its epithelial origin, appears to have a glandular structure But the cells making up the organ are not of uniform structure and staining reactions The cells are usually classified on the basis of their reactions to stains, such as (1) chromophile, and (2) chromo phobe The first group is again subdivided into acidophile and basophile cells

Whether these three groups of cells in the anterior lobe represent three

the third ventricle. The theory is accepted by Cushing and Goetsch and by Cow, and they report the presence in the cerebrospinal fluid of a pressor substance identical in character with pituitrin. But the results of Cushing have not been confirmed (Carlson and Martin). There is no demonstrable trace of pituitrin in the cerebrospinal fluid of the normal dog. Wulzen supports the theory of a direct absorption of the pituitary secretion by the lymph vessels and blood vessels. Herring himself has shown that in some animals there is no passage of colloid into the hypophyseal stalk. And as for the view that the colloid constitutes the important secretion, tests on the colloid found in the hypophyseal cleft show it to be physiologically inert, at least on the circulation.

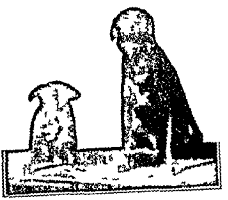

Fig. 13. Twelve months old Hypophysectomized Dog (left) and Control of Same Litter (right). The operation was performed at [illegible] weeks. (Aschner.)

Accessory Hypophysis.—Small nodes of glandular tissue apparently identical with the anterior lobe are present in many animals, including man, as the so-called pharyngeal hypophysis. If this pharyngeal hypophysis actually represents part of the original connection of the intracranial hypophysis with the pharyngeal ectoderm, we would expect it to exhibit evidence of functional changes synchronously with the anterior lobe. Unfortunately but little attention has so far been given to this by clinical and experimental workers. Nodules of glandular tissue inside the cranial cavity in the neighborhood of the hypophysis proper have been described by Dandy and Goetsch under the name parahypophysis.

The most important steps in the development of the knowledge of the functions of the hypophysis were the following. The observation (beginning with Rogowitsch, 1889) that extirpation of the thyroid, the gonads or the pancreas leads to a hypertrophy of the hypophysis; the report of Marie (1886) of an association between acromegalia and anatomical changes in the hypophysis; the discovery (beginning with Oliver and Schafer, 1895) that extracts of the gland have marked effects upon the blood pressure, the heart and the smooth musculature of the body in general, especially the uterus; the report of Frolich (1901) of an apparent relation between the hypophysis and the condition known as dystrophia adiposogenitalis; the report (by several investigators but especially by Paulesco 1907, Cushing 1909 and Aschner 1912) that the total or nearly total extirpation of the gland is followed by death or by char

is by no means constant throughout life There appears to be an increase in the chromophile cells at puberty and during pregnancy, and a gradual diminution of them after the fortieth year of life, indicating an adjustment of the organ to metabolic rate and possibly to sex life

Gemelli, Cushing and Goetsch report that, in hibernating animals during hibernation, the hypophysis decreases in size, and the cells of the anterior lobe lose their characteristic staining reactions to acid and basic dyes At the end of hibernation the gland again enlarges, cell division is in evidence and the cells regain their normal staining reactions On the basis of these findings they accept the theory of Salmon that the depression of the activity of the hypophysis is the primary factor in causing hibernation, especially since partial hypophysectomy is said to induce depression obesity, and somnolence in non hibernating animals It must be noted, however, that the completely or nearly complete hypophysectomized dogs of Aschner, some of which lived over a year, did not hibernate Their appearance did not even suggest the condition of semi hibernating animals The more recent experiments of Mann and Rasmussen failed to confirm the hibernation changes in the hypophysis described by Gemelli and by Cushing and Goetsch "There is no basis for the theory ascribing the phenomena of hibernation to lack of function of any or of all the endocrine glands"

According to Fenger, the formation of solid colloid in the pituitary gland does not occur during the growth period, but is a phenomena of adult life The solid colloidal material in the clefts of the pars intermedia is insoluble in Ringer's solution and is physiologically inert.

The hypophysis has a very rich blood supply According to Dandy and Goetsch, the anterior lobe receives the blood supply from eighteen or twenty small arteries from the various components of the circle of Willis These vessels immediately break up into numerous large sinusoidal channels, in apposition with the gland cells and lined only by endothelium "Hence there are no veins or arteries proper in the anterior lobe substance" The pars intermedia derives its blood supply from the vessels of the stalk, from the posterior lobe, and from the adjacent brain The posterior lobe is supplied by an artery derived from the internal carotid

A clear knowledge of the hypophyseal circulation is necessary for the interpretation of the results of surgical interference (experimental and clinical) with this organ From the sympathetic carotid plexus nerve fibers pass to the hypophysis, particularly the anterior lobe (Dandy) It is not known whether these nerves have vasomotor, secretory, or sensory function

On the assumption that the colloid of the posterior lobe constitutes the internal secretion of this part of the gland and the relation of these colloid masses to the cells and fibrous tissue, Herring has advanced the view that this secretion is normally discharged into the cerebrospinal fluid of

epinephrin depends upon the sympathetic innervation and so, under some circumstances causes a relaxation Epinephrin stimulates the endings of the sympathetic nerves of the heart causing an acceleration and augmentation of the heart beat, pituitary extract causes a slowing and at first a strengthening of the beat but this soon gives place to a weakening The latter effect is probably due in part to the constriction of the coronaries, this is antagonized in the intact animal by the rise of blood pressure, so that the secondary weakening of the beat is not usually observed

Howell made the interesting observation that a second injection within one-half to one hour does not cause a second rise of blood pressure it may even cause a fall Later a rise again is observed This observation is of importance in connection with the therapeutic use of the extract. It is not a true immunity according to Dale but small doses can be injected repeatedly at intervals of ten to fifteen minutes without significant failure of their pressor effect (Hoskins and McPeek) The active principle is excreted in the urine

The rise of blood pressure following injection of posterior lobe extract takes place after removal of the adrenal and is therefore not a secondary effect due to increased secretion of epinephrin

Krogh has reported experiments intended to show that the hormones of the posterior lobe (pituitrin) control the tonus of the blood capillaries

Von Frankl Hochwart and Frohlich found an increased irritability of the automatic motor nerves of the bladder on faradic stimulation Similarly the irritability of the hypogastric nerves to the uterus was much increased These effects were produced only by the first injection of the extract

Magnus and Schafer and also Schafer and Herring reported that the intravenous subcutaneous or intraperitoneal injection of extracts of the posterior lobe caused marked and long continued diuresis and dilatation of the kidneys According to the same authorities administration by the mouth also increased the amount of urine secreted both in animals and in man.

There has been considerable discussion as to whether this diuresis is due to a direct action upon the cells of the kidney or is brought about indirectly through changes in the circulation Schafer and Herring and also Hoskins and Means support the view that the action is primarily on the kidney cells directly and only secondarily aided by the changes in the circulation while Houghton and Merrill and also King and Stoland conclude that it is purely a vascular phenomena the pituitrin diuresis running parallel with the vasodilatation in the kidneys

The statement of Schafer that the administration of posterior lobe extract by mouth induces diuresis has not been substantiated by recent

acteristic effects upon growth and development, the relation of the hypophysis to renal activity (beginning with Schafer, 1906) and to diabetes insipidus, the studies on the influence of feeding hypophysis on general growth, and on development of the gonads (Schafer, 1909, Goetsch, 1916, Robertson, 1916) It should be noted, however, that the reliability of much of the above work (experimental and clinical) has been seriously challenged, especially by Camus and Roussy Their work indicates that the hypophysis is not an important endocrine organ, the symptoms usually ascribed to hypopituitarism being due to injury to the tuber cinereum and the base of the midbrain

Function of the Posterior Lobe and the Pars Intermedia—These two parts of the gland must at present be considered together, because, though differing in structure and origin, they are anatomically so closely interwoven that they cannot be separated for experimental purposes

Action of the Extract—Oliver and Schafer found that extracts of the entire gland raised the blood pressure Howell subsequently showed that these effects were due entirely to the posterior lobe Schafer and Herring Herring, Cushing and Goetsch, Lewis, Miller and Mathews, have found that the active principle seems to be formed in the pars intermedia, from which it passes into the posterior lobe It is also possible that the presence of the pressor substance in the posterior lobe is due to the pars intermedia cells distributed among the neuroglial cells and fibers In adult humans there appears to be no true pars intermedia, yet the posterior lobe contains the pressor substance

The most marked physiological action of extracts of the posterior lobe is to cause a constriction of smooth muscle The constriction of the arteries following the administration of such extracts leads to a marked, and, as compared with the effect of epinephrin long continued, rise of blood pressure The extracts also cause dilatation of the frog's pupils, strong contractions of the uterus and of the alimentary tract

There is thus some resemblance between the effects of extracts of the pituitary and of the adrenal medulla, this is, however, only superficial The effect of epinephrin upon organs containing smooth muscle is generally the same as that of the stimulation of the sympathetic nerves supplying these organs, when the sympathetic causes inhibition instead of contraction, epinephrin does the same The effects of pituitary extracts are entirely independent of the sympathetic nerves, they are exerted directly upon the muscle cells (Dale) The action of pituitary extract is more nearly like that of the digitalis series, but the effect on smooth muscle is much greater than on the heart muscle Hence, the effects of the two drugs are in many instances different Thus, the pituitary causes marked constriction of the coronary and pulmonary vessels, epinephrin has but little effect upon these Pituitary extract always causes marked contraction of the uterus, whether this is pregnant or at rest, the effect of

stance of the action of posterior lobe substance on smooth muscle and is of no practical importance in pediatrics and gynecology

Weed and Cushing recently reported that extracts of the posterior lobe of the hypophysis increase the rate of production of cerebrospinal fluid (choroidorrhea) by stimulating the secretory activity of the choroid plexus But Becht has shown that the apparent increase in the cerebrospinal fluid after such injections is due to circulatory and respiratory changes following the pituitrin injection, and not to an increased secretory activity Cow reports that extracts of duodenal mucous membrane stimulate the posterior lobe to increased secretion His experiments are not convincing

Posterior lobe extract, intravenously injected, has a direct action on the respiratory center causing usually an increase in depth of the respiratory movements followed by shallow and slow respiration (Nice Rock and Courtright) It decreases the rate of secretion of the saliva (Stoland and Lommen)

Continued daily injections of posterior lobe extract are very deleterious, leading to emaciation, depression fever tissue changes—especially in the liver—vascular disturbances etc Harvey reports sclerotic changes in the coronary vessels after repeated injection of pituitary extract This is of great practical importance *It is evident that the various posterior lobe extracts so far prepared do not represent the normal secretion or substance passed into the blood by the gland or else these substances are contaminated by injurious split products of the cell constituents*

The specific pressor substance in the posterior lobe and pars intermedia is in evidence in early fetal life in cattle it can be demonstrated at the eighth week of gestation (McCord) In the pig fetus only 175 millimeters in length, the pressor substance is very abundant (Lewis) If this substance represents an actual internal secretion, the gland is evidently functioning during intra uterine development

The active principle or principles of the posterior lobe have not been isolated, and little is known as to their chemistry They are dialyzable, are not destroyed by boiling and are soluble in water and ethyl alcohol (Fenger) they resist peptic but not tryptic digestion They do not give the color reactions characteristic of epinephrin although they seem to give certain decomposition products analogous to those of this compound The colloid masses present in the adult s posterior lobe and in the pars intermedia are physiologically inert (Lewis Miller Mathews Loth, Fenger) There is no iodin either in the anterior or the posterior lobe even after complete thyroidectomy (Wells, Simpson and Hunter), but some posterior lobe extracts on the market are reported to contain iodin Relatively large amounts of calcium and phosphorus are present besides traces of arsenic and bromin (Biedl) cholin guanin histidin, and histamin have been reported (England and Kutscher, Aldrich Abel and Nagayama Jackson and Mills) Koessler and Hawk maintain that

workers In fact Orlandi, Konschegg, Hoppe Seyler, Fry, Mozfeldt, Rees and others report that feeding, but especially hypodermic injection, of posterior lobe extract decreases the urine volume both in normal persons and in various conditions of polyuria, such as diabetes insipidus, without influencing the total solids excreted *Injection* (hypodermatic) *of posterior lobe extract appears now to be an established therapy for temporary control of diabetes insipidus* This may be a drug action rather than an endocrine action But so far as the posterior lobe of the hypophysis is related to diabetes insipidus, it is lack of the secretion rather than the excess of it that leads to the polyuria When the extract is given by mouth or hypodermatically, the absorption is too slow to induce vascular changes and, hence, the temporary diuresis seen on intravenous injection does not appear *How pituitrin checks diuresis and reduces the* urine volume in normal persons and in polyuria is still an open question Rees has reported work indicating that pituitrin slows the absorption of water from the intestines

Borchardt, Goetsch, Cushing and Jacobson found that injection of posterior lobe extract may induce hyperglycemia and glycosuria, analogous to the action of epinephrin It is not yet known whether the temporary glycosuria obtained by some observers is secondary to the disturbances in circulation, or is an index of a primary and special relation of the posterior lobe to carbohydrate metabolism Falta, Franchini, Guidri, Masi and others maintain that the administration of posterior lobe extract does not induce hyperglycemia or glycosuria Intravenous injection of extracts of fresh pituitary gland, the anterior or the posterior lobes, or the implantation of the entire fresh gland into the animal does not produce glycosuria in the dog This is at least true of the quantity of the hypophysis represented by from two to ten glands of the dog (Carlson and Martin)

Alleged Galactagogue Action of Posterior Lobe Extract—In 1910, it was reported by Ott and Scott, and subsequently confirmed by Schafer and Mackenzie, Maxwell and Rothera, and a number of other observers, that injection of posterior lobe extract into lactating animals and lactating women causes a temporary flow of milk from the nipple This was first thought to be a true "lactagogue" action, and, hence, of great practical importance in medicine But Ott and Scott reported a similar "lactagogue" action from the injection of thymus, pineal gland, and corpus luteum extract and it was soon discovered that on continual administration of posterior lobe extract there is no increase in the total milk yield either in experimental animals or in women And it has now been demonstrated (by Gaines and others) that the apparent lactagogue action of hypophysis extract is due to the contraction of the smooth muscle in the duct system forcing out any milk already formed in the gland, and not a stimulating action on the milk producing cells It is another in

young rats weighing 25 to 50 grams is equivalent to a daily dose of 150 to 300 grams dried gland in a person weighing 60 kilograms—a quantity far in excess of the total daily protein requirements of the individual It would thus seem that the e experiments are far outside the range of organotherapeutic possibilities for man Feeding experiments must be made with smaller doses

Function of the Anterior Lobe—Most of our knowledge of the physiological importance of the anterior lobe has been secured by the method of extirpation, feeding the gland transplantation, direct stimulation and from diseases (tumors and cysts) of the organ.

Alleged Growth controlling Principle of Anterior Lobe—*Tethelin*—Apart from the fact that extracts of the anterior lobe like tissue extracts in general, cause on intravenous injection a temporary lowering of the blood pressure (Hamburger) nothing of importance has been gained by this line of study of the anterior lobe Robertson isolated a mixture of substances, from the anterior lobe, which according to him has the same stimulating action on growth as the entire gland and hence named by him *tethelin*. But the influence of anterior lobe feeding on growth is still an open question Tethelin contains 1 4 per cent phosphorus and nitrogen in proportion to four atoms for every atom of phosphorus some of the nitrogen being present in amino groups It probably contains an imidazolyl group, and to this extent may be regarded as related to the physiologically active substance of the posterior lobe But tethelin does not possess the characteristic physiological activity of the posterior lobe extract, for large doses given intravenously have only a slight depressor action on the blood pressure and practically no action on the heart the uterus or the musculature of the alimentary tract *Tethelin has as yet no proved therapeutic value*

Extirpation of Anterior Lobe—The literature on the effects of partial and complete removal of the hypophesis since the first paper by Horsley (1886) to the extensive work of Aschner (1912) is as extensive as it is contradictory Part of the conflicting results are due to the difficulties of the operation (extensive hemorrhage injury to the brain etc) There is no doubt that removal of the gland by the buccal route is in the hands of skilled experimenters, attended with less brain injury than the cranial route of Paulesco and Cushing The most instructive results are those reported by Cushing and his coworkers, Sweet and Allen Aschner Smith Camus and Poussy Their studies viewed in the light of the entire literature, appear to warrant the following conclusions

1 Cutting the stalk of the infundibulum, or removal of as much of the posterior lobe and pars intermedia as is possible without too great injury to the anterior lobe has no marked effect on the animal except possibly some tendency to adiposity due to injury to the base of the brain.

there is no histamin in the fresh posterior lobe Crystalline substances showing some of the characteristic activities of posterior lobe extract have been isolated by Aldrich, Houssay, and especially by Fuhner, the latter investigator was able to isolate four crystalline substances exhibiting physiological activity These were named collectively, by Fuhner, "hypophysin"

The commercial preparation "pituitrin," is an extract of the posterior lobe One cubic centimeter is said to correspond to 0 1 gram of the fresh or to 0 1 gram of the dried gland "Pituitary liquid" is said to be a 20 per cent extract of the fresh gland

Standardization of Posterior Lobe Extracts—Roth (1914) found that the various commercial preparations of the posterior lobe on the market varied greatly in physiological activity, some being fifteen times stronger than others This is a very serious situation, in view of the increased use of this extract, especially in obstetrical practice, and because of the serious consequences (such as rupture of the uterus, etc) that may *follow the administration of too large a dose In view of the fact that* there is no seasonal variation in the activity of the posterior lobe, and little or no difference in the activity of the gland from different species of animals (cattle, hogs), the actual variations in the strength of preparations must be due to faulty processes of manufacture It evidently does not suffice to state the strength of the preparation in terms of the percentage of fresh or dried gland present Roth has demonstrated a practical *method of standardization by comparing the extract (using a guinea* pig's uterus as a test object) with a definite dilution of histamin But Abel and Rouiller have recently reported the isolation of a substance from the posterior lobe having forty times the action of equal quantities of histamin

Posterior lobe extract has become a useful drug in labor It is obvious that such standardization of posterior lobe extracts for clinical uses would *make the substance safer*

Feeding Experiments with Posterior Lobe—These have so far thrown little or no light on the physiology or possible therapeutic use of the organ Caselli, Sandri and Goetsch report retardation of growth in young animals on continued feeding Aldrich, Lewis and Miller noted no effect on growth or health condition of the animals fed Behrenroth obtained indications of increased rate of maturation of the gonads *Goetsch states that feeding the dried powdered posterior* lobe extract to young rats in daily doses of 0 1 gram causes failure to gain in weight, increased peristalsis, mild enteritis, and certain nervous manifestations such as muscular tremors and weakness of the hind limbs These effects are not produced by smaller doses (0 05 gram per day) These smaller doses have no effect on growth but seem to retard the development of the sex glands A dose of 0 05 gram dried pituitary per day given to

Cushing interprets the results as due to an excessive liberation of posterior lobe secretion into the blood by the stimulation of the gland. Using more accurate methods Keeton and Becht showed that while direct stimulation of the gland induces hyperglycemia and glycosuria this does not occur in animals with section of the spinal cord or the splanchnic nerves —a fact which argues against the liberation of an hypophysis hormone which increases directly the glycogenolysis in the liver. The question of the possibility of inducing excessive hypophysis activity by direct mechanical stimulation of the gland is of great practical importance in cases of head and brain injuries and brain tumors in man.

Alleged Secretory Nerves to the Hypophysis.—This question is as yet an open one, owing in part to the fact that we have no certain test of hypophyseal hyperactivity in crucial experimental stimulations lasting at the most a few hours. Weed, Cushing and Jacobson and Shamoff reported that stimulation of the cervical sympathetic nerve and especially the superior cervical ganglion in rabbits induces glycosuria. This they interpret as due to the stimulation of secretory nerve fibers passing from the cervical sympathetic to the posterior lobe. Although using more accurate methods Mabens and Lifschitz failed to confirm Cushing's results.

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In another report Robertson and Burnett state that injection of an emulsion of the anterior lobe into tumors (carcinomata) in mice increases the rate of the tumor growth without increasing the tendency to metastases. Wulzen reports further that the growth of planarian worms is accelerated by a diet of anterior lobe and pars intermedia provided the feeding is begun early in life. Any part of the hypophysis increases the rate of fission in these lowly forms. Robertson also states that hypodermatic

2 Complete or nearly complete removal of the anterior lobe in young animals leads to retardation of growth, especially of the skeleton, prevents maturation of the gonads, thus causing failure of development of the secondary sex characters, causes depression, sluggishness and somnolence, a tendency to excessive obesity, a lowered rate of metabolism and possibly some increase in the carbohydrate tolerance hyperplasia of the thyroid, thymus, and the cortex of the adrenals, it shortens the span of life

3 *The anterior lobe appears to be necessary for normal growth and development*, but its removal is not fatal The death of hypophysectomized animals, as reported by many workers, within two to five days of the operation, *with symptoms of extreme depression, is probably due to* hemorrhage and brain injuries At any rate it does not appear to be due to the loss of the anterior lobe Complete removal of the posterior lobe and pars intermedia is more difficult without injury to the base of the brain

4 In the adult animal complete or partial removal of the anterior lobe may induce a temporary hyperglycemia and glycosuria, excessive deposition of fat, progressive atrophy of the gonads and the sex characters, and various histological changes in the other endocrine glands

5 In most cases partial removal of the hypophysis, or mere operation in the region of the hypophysis, induces a temporary diabetes insipidus

6 It is, at present, impossible to state what part of the symptoms following hypophysectomy is due to brain injuries, what part is due to loss or injury of the gland I have had apparently completely hypophysectomized dogs showing no demonstrable symptoms

Transplantation of the Hypophysis —*In the hands of most observers* the transplanted hypophysis appears to be quickly absorbed without producing any definite effects on the animal Exner reports a temporary *increase in growth when several glands were transplanted into young rats* Cushing and his pupils state that symptoms of complete or partial hypophysectomy are delayed or diminished, at least for a time by transplanting a part of the gland The same author reports favorable results, at least temporarily, from transplantation of a child s hypophysis into the brain of a patient suffering from hypopituitarism due to a hypophyseal cyst There is nothing in the literature to indicate that a transplanted hypophysis becomes permanently functional in the host Nor has it as yet been possible to produce any of the symptoms of acromegaly by implanting excessive amounts of hypophysis into animals

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injections of tethelin stimulate the action of tissue repair as expressed in the replacement of tissue lost during a preceding period of starvation or in the healing of granulating wounds

The extensive studies of Goetsch on white rats seemed to demonstrate that continued feeding of anterior lobe to young animals accelerates body growth and hastens sexual maturity, while similar feeding of posterior lobe retards both growth and sexual development When the anterior lobe is fed to adult rats, sexual activity, as indicated by the number of pregnancies, is augmented Goetsch's work appears convincing but it seems difficult to reconcile his *100 per cent positive results with the negative findings of practically all other investigators* (cf Kriss) Robertson and Wulzen give the impression that the anterior lobe feeding did exert some stimulating action on the sex function in some animals (mice, chickens)

According to Pearl and Surface injection of anterior lobe substance or extract into the peritoneal cavity of fowls does not activate the completely resting ovary Feeding the same to egg laying hens does not accelerate egg production Feeding the anterior lobe substance to young pullets does not bring about an earlier activation of the ovary Feeding anterior lobe substance or desiccated corpus luteum to young pullets *retards growth* but has no effect on the rate of development of sexual maturity Clark, on the other hand, reports that feeding the anterior lobe substance to hens increases egg production as well as the fecundity of the egg This effect becomes evident after three or four days' feeding and persists a few days after ceasing the feeding Clark's experiments are criticized by Pidot Uhlenhuth reports some excess growth of salamander larvae fed on the anterior lobe

The present state of the literature on pituitary feeding of normal experimental animals seems to admit of the following conclusions

1 Feeding anterior lobe may slightly accelerate the growth of young animals but there is no evidence that the final stature is greater than that of the control animals Hence, there is no evidence of experimental acromegalia or gigantism, at least in mammals

2 Anterior lobe feeding is reported to accelerate sexual maturation in the young and stimulate sexual activity in the adult animal, while the posterior lobe has the opposite action But more work is needed before this thesis is established In view of the conflicting literature, we cannot refrain from expressing the fear that some authors may have reported what they thought they ought to have found, rather than impartial objective results Hypogenitalism and retarded growth are ascribed by so many clinicians to impairment or destruction of the hypophysis, hence, that hypophyseal organotherapy ought to produce the opposite results appears so reasonable as to lull scientific critique

Functional Disorders of the Hypophysis Alleged Hyperpituitarism—For some time after the report of a relation between acromegalia and the hypophysis there was much discussion as to whether the disease was due to a condition of hyperactivity of hypo-activity or of a perverted activity of the gland The theory has also been advanced that the pituitary changes in acromegalia are secondary to the bone growths and the general disorders of the body It is now generally held, though not proved that the former is due to hyperplasia and increased activity of the anterior lobe—at least in the early stages of the disease The primary pathological condition in acromegalia is usually one of simple hyperplasia (adenoma) of the anterior lobe—especially an increase in the number of chromophile cells (Lewis, Cseptu, Kahlmeter and others) It frequently shows indications of malignancy At the same time there seems to be at least a functional involvement of the posterior lobe In late stages there may be an extensive degeneration of the gland and this has an important bearing upon the possible therapeutic use of the gland in acromegalia The amelioration which may follow the removal of part of the hypophysis in acromegalia (Hochenegg) affords additional proof that the condition is one of hyperpituitarism At the same time it must be admitted that *the precise relation of hypophyseal activity to acromegalia and gigantism has not yet been established* Cognetto advances the following argument against the generally accepted hyperpituitary theory

1 Cases of acromegalia have been observed without tumors of the hypophysis.

2 Adenomas composed entirely of chromophilic cells of the anterior lobe have been found associated with acromegalia

3 Adenomas of the hypophysis composed entirely of chromophilic cells, but without acromegalia, have also been described [4]

Two sets of symptoms are caused by hypertrophy of the hypophysis (1) those which appear to be due to the specific hyperactivity of the gland (2) those produced by the pressure of a tumor in this region The specific effects supposed to be due to hyperactivity which may throw some light upon the *normal function of the gland* are marked and characteristic changes in the features and in the extremities, due partly to the growth of the soft tissues partly to an enlargement of parts of the bones of the head feet and hands

Keith has studied in detail the changes in the skull in acromegalia and the manner in which they are induced He concludes that an internal secretion of the hypophysis sensitizes tissues so that they respond to the natural stimuli of growth (mechanical activity and muscular movement)

[4] In some cases there are changes in the cranial bones without acromegalia —Ed to

with increased energy The enlargement of the extremities is due largely to connective tissue growth

Among other symptoms of acromegalia are lassitude, muscle pains, apathy, and disturbances (depression) in sexual activity, there may be amenorrhea in women and frequently impotence in men, but excessive sexual activity may also be present Vasomotor changes in the skin are frequent Polyuria, with or without glycosuria, is not uncommon

Borchardt found glycosuria in 40 3 per cent of 176 cases In later stages where the hyperactivity of the gland is being replaced by hypo activity there is, according to Goetsch, Cushing and Jacobson, not only no glycosuria, but an increased tolerance for carbohydrates, but these authors consider both the glycosuria (lowered carbohydrate assimilation) and the subsequent increased carbohydrate tolerance to be due to hyperactivity and hypo activity, respectively, of the posterior lobe

The literature on the condition of metabolism in acromegalia is con flicting, but in the early stages there appears to be a definite retention of calcium, magnesium, and phosphorus (Bergheim, Stewart, and Hawk) probably in consequence of the new bone growth Part of the contra dictory results are probably due to the fact that only the early stages of the disease are associated with hyperactivity of the anterior lobe, and this is followed later by destructive changes in the gland and hypopitu itarism (Tamburini, Schafer) Since pure hyperpituitarism (experi mental hypophysectomy) seems to be followed by some lowering of the rate of metabolism, we would expect an increased rate of metabolism in acromegalia, if it is due primarily to hyperactivity of the hypophysis

The studies of acromegalia show that there is a close relationship between the hypophysis and growth, especially of connective tissue, car tilage and bone, and also between this gland and the activity of the sex glands, thus supporting some of the experimental results on the hypophysis

The relation between the hypophysis and growth has been further
phasiz 1 ed by studies on gigantism in this condition also hyperplastic
ditions mals, b of the hypophysis are frequently found In many of the e
es, however the co other glands of internal secretion are so greatly involved
t it is imposs lia or gible to determine whether the changes in the hypophysis
primary or se rior lob ondary The other glands chiefly involved are the
glands, which may and stim be atrophic and the thyroid In certain cases of
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It is interesting to not essing th in this connection that favorable results in
ocious gigantism have hey or gl been reported from the administration of
, and that the changes i nitalism n the hypophysis in animals following cas
on may be partly preven nent or ted by the injection of testicular extracts
n reports, however, that in raphy oug the albino rat there is no hyperplasia of
hypophysis following spayin scientific while castration of the male induces

the hyperplasia Tandler suggests that the special growth features of eunuchism may be due to the hyperplasia of the thyroid that follows castration But in the rat and the guinea pig the changes induced in the hypophysis by gonadectomy appear to be of the nature of atrophy or degeneration (Addison Moore)

A condition of hyperpituitarism is believed to exist as has already been indicated, after castration which usually leads to some enlargement of the hypophysis, and also during pregnancy when some of the functions of the ovaries are in abeyance There are not only charac-

Fig 14—Adult Dogs Male and Female Some Months after Removal of the Greater Part of the Pituitary Body In each case a control of the same litter is shown on the right of the operated animal The tendency to adiposity is marked in both sexes (Cushing's *The Pituitary Body* J B Lippincott Co)

teristic changes in the hypophysis during pregnancy as indicated by increase in size and by histological changes but certain general symptoms of pregnancy (enlargement of the hands changes in the facies suggestive of acromegalia) are considered to be due to the hyperpituitarism Some of these changes may persist after termination of the pregnancy

Removal of the thyroid also leads to hypertrophy of the hypophysis (Rogowitsch, Levingston) the latter is also found in many cases of hyperthyroidism in man Symptoms referable to the hypophysis have been reported after thyroidectomy

Functional Disorders of the Hypophysis Alleged Hypopituitarism—The condition of hypopituitarism is of interest in connection with the organotherapeutic use of the hypophysis

A condition of hypopituitarism is assumed to exist in the disease "dystrophia adiposogenitalis," first described by Frohlich in 1901. In this condition there are usually hypophyseal tumors or cysts of a destructive character, combined with obesity, a hypoplastic condition of the sex glands and retarded growth or infantilism. Some of these symptoms—notably the obesity—occur also in the later stages of acromegalia.

The view that this condition is really due to a primary involvement (hypofunctioning) of the hypophysis is largely based upon experiments upon animals (Cushing, Aschner) in which the hypophysis was partially removed as detailed above, and on the effects of clinical organotherapy (Beck, Engelbach, Tierney, Timme and others).

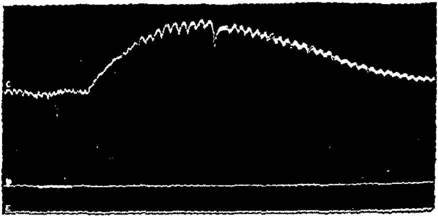

FIG. 15.—TRACING SHOWING THE EFFECT OF INTRAVENOUS INJECTION OF EXTRACT OF THE POSTERIOR LOBE OF THE HYPOPHYSIS ON THE BLOOD PRESSURE. (Schafer.)

Cushing and his coworkers first believed that the above results were due to removal of part of the anterior lobe, later they suggested that some of them (the adiposity and increased carbohydrate tolerance) are chiefly due to removal or injury of the posterior lobe. Bell thinks that the hypophysis acts as a single gland. Beck assumes specific deficiency symptoms both of the anterior lobe, namely (1) retarded growth, (2) obesity, (3) infantilism, (4) hypothermia, (5) cachexia, and the posterior lobe (1) hypotension, (2) increased sugar tolerance, (3) low basal metabolism, (4) asthenia. Engelbach assumes a type of adiposity specific for posterior lobe deficiency. Eddy and others assume that only posterior lobe deficiency induces diabetes insipidus.

It must be admitted, however, that it is not possible to state with certainty, in cases of clinical hypopituitarism, which symptoms are due to lack of anterior lobe and which are due to lack of posterior lobe, or whether any of them are primarily related to hypophyseal deficiency. When the cysts or neoplasms become sufficiently large, it is probable that

the activity of the entire gland is depressed (pressure atrophy) irrespective of the part of the gland giving rise to the tumor The difficulty in the way of hypophysis organotherapy is further increased by the fact that many of the clinical symptoms of hypopituitarism may arise from dystrophy of other glands of internal secretion Thus impairment of growth and dwarfism and retardation of gonad maturation may be due to thyroid deficiency sexual infantilism to primary impairment of the gonad abnormalities in carbohydrate tolerance to disorders of pancreas and adrenals and lowered metabolism and body temperature to a great number of causes Cushing, Falta, Beck Engelbach and others thus recognize a distinct group of cases with hypophysis involvement but showing at the same time signs of pluriglandular dystrophy *The organotherapy of this group is necessarily complicated and is at present purely experimental*

Summary

Experimental work and clinical observations seem to show that the hypophysis is an organ essential to normal life the removal of which may lead in a short time to death the partial removal or disease of which may lead to a condition of retarded growth or infantilism to obesity, to atrophy of the sex glands and other disturbances of nutrition hyperactivity of the anterior lobe (in acromegalia and gigantism) may lead to accelerated and abnormal bone growth, and ultimately to atrophy of the sex glands Nothing is known as to the nature of the action of this part of the hypophysis

The posterior lobe and pars intermedia contain a substance or substances having marked effects upon plain muscle especially that of blood vessels and the uterus and upon the kidney while it thus has important pharmacodynamic actions its role in the normal animal is obscure since it is not certain that this substance is given off by the gland to the body fluids

Therapeutic Uses of the Anterior Lobe—If we assume that the anterior lobe secretes a hormone and if the hormone is absorbed in active form from the alimentary tract thus permitting administration *per os* or when it is prepared in sufficient purity to permit of repeated intravenous intramuscular or hypodermatic injections without untoward symptoms one might hope for favorable results from anterior lobe therapy in all diseases due in whole or in part to impaired functions of the hypophysis (hypophyseal dystrophy, infantilism amenorrhea impotency or impaired growth traceable to the hypophysis) The results of clinical use of the hypophyseal preparations have so far not come up to this expectation. In fact *it has not yet been shown that the effects of partial or complete hypophysectomy in experimental animals can be essentially and permanently counteracted by hypophyseal organotherapy* The past failure

may be due in part to using the entire gland, rather than the anterior lobe, as there is some evidence that *posterior lobe substance counteracts the effects of the anterior lobe substance in some directions* Recent clinical reports record some cases of supposed hypopituitarism in which feeding hypophysis, or hypophysis combined with thyroid, seemed to *improve some of the symptoms (adiposity, general aplasia, somnolence,* etc), while other cases showed no improvement If the diagnosis is correct it is difficult to explain such discordant results We must be particularly careful in cases of *delayed adolescence* for here any therapy *persisted in long enough may seem to be effective, although there may be* no causal connection between the therapy and the change in the patient That thyroid feeding reduces adiposity is well established, but what light

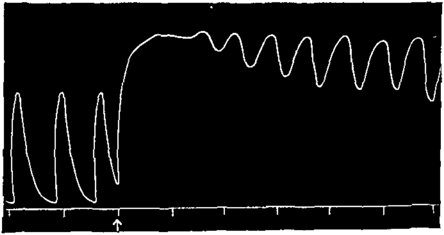

FIG 16—TRACING SHOWING THE ACTION ON AN ISOLATED CORNU OF RAT'S UTERUS SUSPENDED IN LOCKE'S SOLUTION OF THE ADDITION OF EXTRACT OF POSTERIOR LOBE OF OX PITUITARY TO THE SOLUTION (Itagaki)

does that throw on hypopituitarism? In the present unsettled state of our knowledge we must be guided by the following principles

1 Diagnosis of hypopituitarism is in no case certain

2 Feeding *hypophysis* has so far failed to control the symptoms of certain (experimental) hypopituitarism

3 Empirical organotherapy in supposed hypopituitarism is justified, but when pluriglandular mixtures are used we are merely treating a disease of unknown origin with a remedy of unknown composition

The literature shows that, besides the above, hypophysis therapy has been tried with varying results in amenorrhea, menorrhagia, asthma, hemoptysis, insomnia, angina pectoris, osteomalacia, rachitis, rheumatic and gonorrheal arthritis, periostitis, tetany, epilepsy, dementia præcox,

sterility, impotency, exophthalmic goiter, pneumonia, diphtheria, typhoid, hay fever

Therapeutic Uses of Extracts of Posterior Lobe (Pituitrin).—Extracts of the posterior lobe are used chiefly for their effect upon plain muscle, that of the uterus, the gut, and blood vessels, and for the control of the polyuria of diabetes insipidus.

Many recent writers have reported very favorable results from the use of such extracts in uterine hemorrhage. The use of pituitrin in uterine atony, and in postpartum hemorrhage and in other forms, is now well established.

Several writers have advocated the use of pituitary extract to increase the blood pressure in shock and in various infectious diseases (pneumonia, diphtheria, typhoid, etc.), claiming that it has the advantage over epinephrin of a much more lasting effect. But such therapy has proved of no practical value. Reese and others have reported good results from pituitary extract in asthma. This is probably an error except in the so-called "cardiac asthma due to impaired circulation. In true bronchial asthma pituitrin not only has no effect but may be harmful (Koessler).

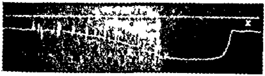

Fig. [illegible].—Tracing [illegible] the Contraction of [illegible] the [illegible] Duct [illegible] Injection of Pituitrin. [illegible] flated [illegible] connect [illegible] teat. [illegible] injection of pituitrin [illegible] chloroform. Time 10 second. [illegible]

Wiggers considers that it is the only drug which meets the indications for a hemostatic in pulmonary hemorrhage, since it raises the blood pressure by peripheral action (which contracts the bleeding points and at the same time prevents anemia of the brain) and causes a weakening of the heart, which prevents a rise of pressure in the pulmonary vessels.

Bell and others recommended it in intestinal paresis after abdominal operations. It is said to act more powerfully on the paretic than on the normal intestine.[*]

Klotz considers it especially valuable in peritonitis, where it not only increases the blood pressure, but stimulates peristalsis.

The drug has been injected subcutaneously or intramuscularly in doses of 1 to 3 c.c. of the aqueous extract, 1 c.c. corresponding to 0.1 or 0.2 gram of the fresh gland (posterior lobe), or intravenously in doses of 1 to [illegible] c.c. diluted with 20 c.c. normal saline solution. There is danger of local necrosis when injections of strong solutions are made subcutaneously.

[*] It is also valuable in the tympanites of pneumonia and other infections.—Editor.

It has also been given by the mouth in doses corresponding to 0.2 gram to 0.8 gram of the fresh gland, or 1 to 3 grams of the dried gland (posterior lobe).

The drug is contra-indicated in all conditions of high blood pressure.

Although serious untoward results from use of pituitrin do not seem to have been reported, except such accidents as uterine rupture from administration of pituitrin in labor before dilation of the os, it should be remembered that Harvey has produced sclerotic changes in the coronary vessels of animals; Crowe has seen loss of weight and marked changes in the liver from repeated injections; Thaon reports pathological changes in the kidney after prolonged use of large doses; and Franchini has observed intestinal ulceration and hemorrhage.

General Summary

While specific hypophyseal organotherapy is still in the experimental stage, our present knowledge appears to warrant the following:

1. Administration (*per os*) of anterior lobe in all cases of supposed hypopituitarism.
2. Possible value of anterior lobe substance (*per os*) as a stimulant to general growth and repair processes.
3. The use of posterior lobe extract (subcutaneously) as a stimulant to smooth muscle (uterus, alimentary tract, cardiovascular system) and as an antidiuretic in diabetes insipidus.
4. Physicians should insist (1) that posterior lobe extract (pituitrin) is physiologically standardized by Roth's or similar methods; (2) and that anterior lobe extract be not prepared from the glands of old animals, as there are indications of gradual atrophy of the gland in old age.

THE OVARIES

Anatomy.—The ovaries of the sexually mature mammalian female contain the following tissues:

1. Ova in varying stages of maturation.
2. Follicular epithelium and liquor folliculi.
3. Corpora lutea, or yellow bodies.

In the ovaries of some species (including man), a fourth element, interstitial cells similar to those of the testes, has been described, but these do not form such a distinct element of the ovaries and are more readily destroyed by the X-ray than are the cells of Leydig in the testes. The ovarian interstitial cells are said to increase during pregnancy and undergo retrogression during hibernation.

The corpora lutea are not present in the ovary before puberty This particular element can, therefore, assume no role in the *development* of the anatomical and physiological characters peculiar to the female sex

Influences of Congenital Absence Atrophy and Extirpation of Ovaries—If the ovaries are removed in the young female the development of all *the secondary sex characters is arrested* *The uterus, fallopian tubes mammary glands and the external genitalia remain infantile* Heat or rut, and, in the primates menstruation do not occur It is

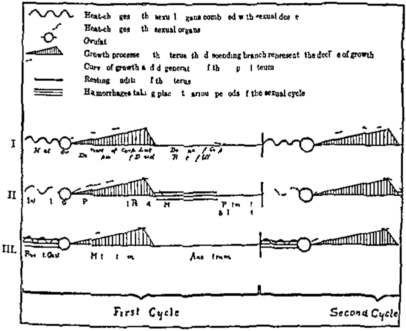

FIG 18—DIAGRAMMATIC REPRESENTATION OF THE SEXUAL CYCLE I In the guinea pig II In apes and women III In the dog (L. Loeb)

claimed that there is a tendency to development of some of the male physical and mental characteristics The metabolism is lowered and in some individuals there is a tendency to adiposity, just as in the castrated male Stotzenburg reports that complete ovariotomy in the very young rat accelerates the rate of growth, at least during the first year Spaying seems to induce less change in other endocrine glands than castration and, strange to say, in some cases the changes are of the opposite character Ovariotomy in the rat leads to decrease in the size of the adrenals while castration causes adrenal hypertrophy In the domesticated white rat (normal) the adrenals and the hypophysis are larger than in the male rat (Hatai) The significance of this is not apparent Ovariotomy in early

It has also been given by the mouth in doses corresponding to 0 2 gram to 0 8 gram of the fresh gland, or 1 to 3 grams of the dried gland (posterior lobe)

The drug is contra indicated in all conditions of high blood pressure

Although serious untoward results from use of pituitrin do not seem to have been reported, except such accidents as uterine rupture from administration of pituitrin in labor before dilation of the os, it should be remembered that Harvey has produced sclerotic changes in the coronary vessels of animals, Crowe has seen loss of weight and marked changes in the liver from repeated injections, Thaon reports pathological changes in the kidney after prolonged use of large doses, and Franchini has observed intestinal ulceration and hemorrhage

General Summary

While specific hypophyseal organotherapy is still in the experimental stage, our present knowledge appears to warrant the following

1 Administration (*per os*) of anterior lobe in all cases of supposed hypopituitarism

2 Possible value of anterior lobe substance (*per os*) as a stimulant to general growth and repair processes

3 The use of posterior lobe extract (subcutaneously) as a stimulant to smooth muscle (uterus, alimentary tract, cardiovascular system) and as an antidiuretic in diabetes insipidus

4 Physicians should insist (1) that posterior lobe extract (pituitrin) is physiologically standardized by Roth s or similar methods, (2) and that anterior lobe extract be not prepared from the glands of old animals, as there are indications of gradual atrophy of the gland in old age

THE OVARIES

Anatomy —The ovaries of the sexually mature mammalian female contain the following tissues

1 Ova in varying stages of maturation
2 Follicular epithelium and liquor folliculi
3 Corpora lutea, or yellow bodies

In the ovaries of some species (including man), a fourth element, interstitial cells similar to those of the testes, has been described, but these do not form such a distinct element of the ovaries and are more readily destroyed by the X ray than are the cells of Leydig in the testes The ovarian interstitial cells are said to increase during pregnancy and undergo retrogression during hibernation

Halban reports successful ovarian transplantation in experiments upon monkeys

All workers in this field agree on the main points The ovarian transplant as long as it lives, maintains all the hormone functions of the ovaries in their normal position These functions are, therefore, internal secretion processes, that is, primarily humoral, not nervous reflexes

Clinical—Ovarian transplantation homotransplantation and heterotransplantation in women has been resorted to extensively in recent years mainly to control the artificial menopause symptoms due to ovariotomy or to atrophied or diseased ovaries (Morris Glass, Dudley, Kramer Tuffier Martin and others) Clinical results have not been as uniformly successful as those on experimental animals probably for these reasons (1) In many instances the ovarian graft was not normal to start with (infection etc) (2) In other cases the state of health and nutritive condition of the women receiving the graft were below par—and this militated against a successful take ' (3) Many surgeons have made the mistake of transplanting an entire ovary instead of one or more small pieces of it The entire ovary is so large that there will be autolysis and complete destruction of most of the transplanted organ before blood vessels have had time to grow in to maintain its life

As in the experimental work, autografts have proved more useful than heterotransplants But Martin notes that either type of transplant may undergo cystic degeneration So long as a sufficient quantity of ovarian tissue remains the transplant is able to sustain normal sex life, including menstruation But at the best *ovarian transplantation for clinical purposes is so far only a temporary expedient* The cause of the ultimate atrophy of the ovarian graft, once adequately vascularized is not known

Chemistry of Ovarian Extracts—The ovary produces in all probability, several hormones but none of them has so far been isolated and chemically defined or detected in the blood although Youatt claims that cows can be brought on rut by feeding them milk from cows in rut Lillie has shown that the mature ova of certain invertebrates secrete a substance which acts on the sperm to render it capable of penetrating and fertilizing the ovum In the absence of this substance union of ovum and sperm does not take place This substance thus appears to act like the opsonins in phagocytosis The substance is named fertilizin by Dr Lillie It can be extracted from the ripe ova by various means and thus shows some stability It is likely that similar fertilizins have a role in the processes of union of sperm and ovum in the vertebrate including man but this hormone or secretion is obviously not concerned in the development and maintenance of sex life, as ripe ova are not present before adolescence and after adolescence they are present only at definite periods

Hermann reports that he has isolated a pentaminphosphatid from the

pregnancy does not influence the cause of the pregnancy or the subsequent lactation But in mice the incidence of mammary gland cancers is reduced by ovariotomy, and spaying retards the postpartum involution of the uterus Moore reports that, in the guinea pig spaying of the young animal leads to *decreased* growth of the hypophysis, the adrenals and the spleen, and a slight *increase* in the thyroid

Ovariotomy in the adult and sexually mature female leads to atrophy of the anatomical sex characters of the female, suppression of all sex functions and most sex behaviors and, in women, to some of the mental and physical symptoms of the natural menopause, such as nervous and circulatory disorders The persistence of menstruation in women after supposedly complete surgical ovariotomy is obviously due to ovarian remnants This is all the more evident since the clinical literature contains instances of pregnancy occurring after complete ovariotomy, which, of course, would otherwise be absolutely impossible In adult bitches ovariotomy leads to a heightened excitability of the sympathetic nervous system (Hoskins and Wheelon), this may be the condition that causes the nervous and circulatory disturbances of the artificial menopause in women

Ovarian Transplantation—*Experimental* —In all species so far tried the ovaries may be successfully removed from their normal position to other parts of the body and continue to maintain their normal functions for considerable periods Transplantation from one individual to another of the same species appears to yield only a temporary success, although Steinach and Sand report grafting of ovaries into castrated males, and testes into spayed female guinea pigs, the transplants living and functioning *long enough to develop female behavior in the original males and* male behavior in the original females Marshall and Jolly, working on rats, found that the transplanted ovarian tissue exhibited all the histological features of normal ovarian tissue, except that the germinal epithelium was invariably absorbed after a short time In some cases other degenerative changes took place The stroma might remain normal, while all the follicles had disappeared, or the greater part of the graft might be composed of luteal tissue alone A point of great importance, noted by these investigators, is that the ovarian transplant undergoes *the same* cyclic changes *as* the normal ovaries In animals killed shortly before the breeding season, large follicles were found in the graft, while a little later corpora lutea were present, showing that ovulation had occurred in the transplant This has recently been confirmed by Moore on rats and guinea pigs *Moore has also succeeded in grafting ovaries into normal males having intact testes* The ovarian graft in the male becomes vascularized, grows and undergoes the normal cyclic changes In one case a homoplastic ovarian graft was found healthy after fourteen months The longest time noted for a heterotransplanted ovary was six months.

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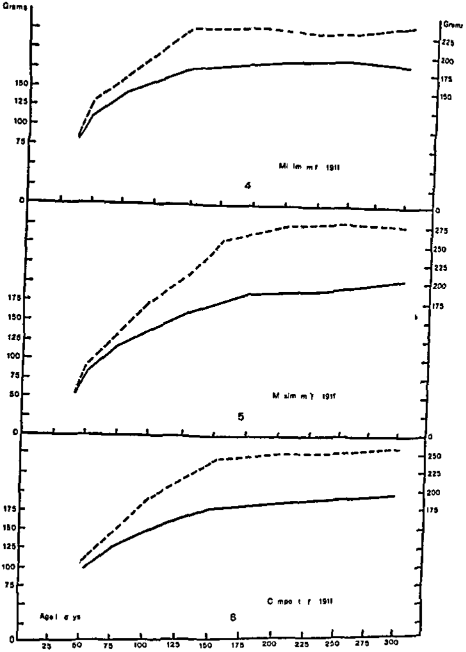

FIG 19 —EFFECT OF SPAYING ON GROWTH IN THE WHITE RAT Solid line represents control broken line represents spayed rats of same litter (Hatai)

corpus luteum. He claims that injection of this substance into animals causes hyperemia of the uterus

Seitz, Wintz and Fingerhut report that they have isolated two physiologically active substances from the corpus luteum (1) a *luteolipoid* and (2) *lipoprotein* or lecithalbumin called lipamin They state that the injection of the latter into animals stimulates the growth of the genitalia, while its injection into women suffering from amenorrhea induces menstruation The luteolipoid on the other hand, is said to decrease the menses, and therefore be useful in menorrhagia, especially the excessive menstruation of puberty We may remark that these two bodies were not chemically isolated and identified and the clinical findings are not conclusive For example, the amount of the menses is not accurately determined According to the theory proposed by Seitz Wintz and Fingerhut normal menstruation is a function of the proper balance of the 'luteolipoid' and the "lipamin' secretions of the corpus luteum This seems untenable for the following reasons (1) These substances were prepared from the corpora lutea of animals that do not menstruate (2) In women menstruation is usually suppressed by pregnancy despite the persistence and great development of the corpus luteum of pregnancy (3) Menstruation (or rut) may precede ovulation and hence may precede the appearance of corpora lutea Doisy and Allen have recently reported the isolation of a hormone from the liquor folliculi that appears to control estrus in animals

Specific Role of the Corpus Luteum—The sex life of the mature mammalian female is much more complex than that of the male. With it are associated ovulation gestation and the nursing of the newly born A very complicated situation is the practical absence of menstruation in all mammals below the primates the relative scantiness of menstruation *in all* primates below man and the apparently serious symptoms associated with amenorrhea as well as menorrhagia in women It is possible that amenorrhea *per se* may not be serious but that the symptoms are due to the underlying causes that suppress the menses Menorrhagia is, of course serious by itself in that it may produce anemia There is no question but that menstruation in women is primarily a function depending on the mature and normal ovary Does the fact that menstruation occurs in women, but not in the lower mammals, indicate a fundamental difference in ovarian physiology in the primates? The answer to this question is *of fundamental importance to practical ovarian organotherapy* as the only available material for such therapy is the ovaries of the lower mammals So far as we know ovarian materials from the apes have not been tried, clinically

The corpus luteum is a temporary organ essentially of the mammalian ovary but it is also present in birds The obvious parallelism of this organ with menstruation and pregnancy has naturally directed experi

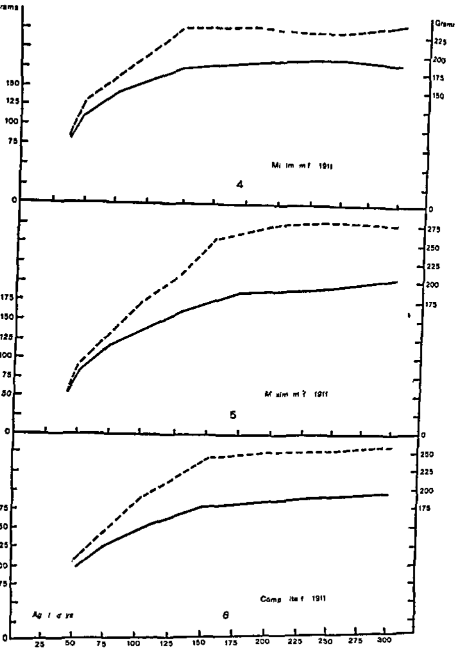

Fig 19 —Effect of Spaying on Growth in the White Rat Solid line represents control broken line represents spayed rats of same litter (Hatai)

injections of fetal and placental extracts into virgins al o cause hyperplasia of the mammary gland

4 Experimental work does not support the view of Frankel that the corpus luteum induces or controls e trum or menstruation as in some animals, at least the proestrous and estrous uterine hyperemia precedes ovulation and therefore takes place in the ab ence of corpora lutea in the ovary

Alleged Antagonism between Testicular and Ovarian Hormones—While the sex life especially of the mammalian female is more complex than that of the male, the essential nature of the sex urge appears to be the same in both sexes This would seem to indicate similar or identical sex hormones The sex urge and the development and maintenance of the secondary sex characters depend on the ovaries and testes, and given the different embryological substrate for the characters it would seem that these might be timulated to normal development by identical hormones Recent experimental work does not support this view The essential hormones of the ovaries and testes appear not only to be different, but mutually antagonistic, at least in certain stages of development and yet they produce, directly or indirectly the same or similar mental states in male and female

We have already referred to the work of Steinach Riddle Sand, Moore and others, of producing 'maleness in the female and femaleness' in the male by changing the gonads or administration of gonad extracts of the opposite sex But the most significant contribution to this subject has been reported by Lillie Lillie s work was done on the freemartin The term freemartin' is applied to the female of hetero sexual twins of cattle It is well established that such females are usually barren Lillie finds that a twin pregnancy in cattle is almost always a result of the fertilization of an ovum from each ovary development begins separately in each horn of the uterus The rapidly elongating ova meet and fuse in the main body of the uterus at some time between the 10 millimeter and the 20 millimeter stage The blood vessels from each side then anastomose in the connecting part of the chorion a particularly wide arterial anastomosis develops so that either fetus can be injected from the other The arterial circulation of each also overlaps the venous territory of the other, so that a constant interchange of blood takes place If both are males or both are females no harm results from this but if one is male and the other female the reproductive system of the female, especially the ovaries, is largely suppres ed, and certain male organs develop in the female This is according to Lillie unquestionably to be interpreted as a case of hormone action The sterilization of the female by the male appears to be due to more precocious development of the fetal male hormones There is no dominance of testes hor-

mental and clinical attention to this organ as a factor of control in these processes The work of Frankel, Marshall, and Loeb appears to have established the following facts

1 *The corpus luteum is necessary for uterine changes involved in the implantation and early stages of growth of the fertilized ovum.* Ovariotomy or destruction of the corpus luteum by cautery in early pregnancy (first few days or weeks, the time varying in different species) invariably terminates the pregnancy When the corpus luteum is destroyed or the ovaries removed later the course of the pregnancy or the hypertrophy of the mammary gland is not interfered with The latter statement is also confirmed by clinical results Ansel and Bouin, and especially Loeb, have shown that these changes in the uterus induced by ovulation and the corpus luteum do not appear to depend on the fertilization of the ovum

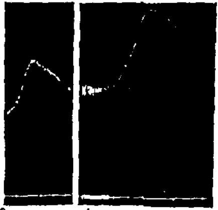

FIG 20—RECORD OF DOG SHOWING RE ACTION TO 0 5 CUBIC CENTIMETERS NICOTIN (1 2 000 DILUTION) *a* BEFORE AND *b* 46 DAYS AFTER EXTIRPATION OF THE OVARIES Blood pressure from femoral artery Time 5 *seconds* (*Hoskins*)

It must be remembered, however, that there is some hypertrophy of the ovarian stroma parallel with the development of the corpus luteum of pregnancy, and from the further fact that the luteal cells are derived from the stroma, there remains the possibility that the stroma cells share in the above role of the yellow body in early pregnancy

2 The corpus luteum of pregnancy appears to delay the maturation of the ova, thus preventing ovulation This is probably not entirely a local action on the ovary, for a well-developed corpus luteum on one ovary appears to be able to inhibit ovulation in the ovary of the opposite side Pearl and Surface report that administration of corpus luteum to hens causes a temporary inhibition of ovulation

3 *The corpus luteum appears to play a part in the hyperplasia of* the mammary gland that occurs during pregnancy (Ansel and Bouin, O Donoghue, Hammond and Marshall, Ott and Scott) It is stated that if the graafian follicle of a virgin rabbit is ruptured by mechanical means, so that a corpus luteum is formed, hyperplasia of the mammary glands is produced, and also that administration of corpus luteum to virgin animals induces hyperplasia But the situation is complicated by the findings of Miss Lane-Claypon and Starling, and of Aschner, that similar

injections of fetal and placental extracts into virgins also cause hyperplasia of the mammary gland

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mones over ovarian hormones after birth or in adults At any rate Moore reports that successful testes graft in female rats does not influence the ovaries in the sex life (rut, pregnancy, lactation, etc.)

If these observations and interpretations of Lillie are confirmed and extended to other animals, we have the extraordinary fact of the development of specific gonad hormones before the gonads have undergone any appreciable differentiation If this shall prove to be the case, these hormones can be produced by nothing else than the primitive germ cells

We have evidence that other endocrine glands (pancreas, thyroid) assume functional importance sometimes during intra uterine life, but the observations of Lillie place the beginning of fetal hormone equilibrium earlier than hitherto thought possible It also raises the question of the exchange of gonad hormones between the fetal and the maternal blood The bearing of a male child obviously does not influence the sex life of the mother Lillie's interpretation of the genesis of the freemartin is called in question by the condition of true hermaphrodism—ovaries and testes being present in the same individual, or testes being present with the secondary sex character of the female and vice versa In the lower animals who normally harbor both ovary and testes (ovo-testis) in the same individual or whose gonads may produce sperm during one period and ova at another period, definite secondary sex characters are usually absent

Experimental Administration of Ovarian Extract—We have seen that complete extirpation of the ovaries leads to atrophy of the uterus, mammary glands and other sex characters These are anatomical or objective changes that may be accurately measured It would therefore seem that it ought not to be difficult to decide whether ovarian administration is capable of preventing or diminishing these effects of ovariotomy Nevertheless the literature is conflicting Jentzner and Beutner and also Carmichael and Marshall state that ovarian administration fails to prevent the atrophy of the uterus Okinclutz claims, on the other hand, that the uterine atrophy following spaying is prevented by injections of extracts of the entire ovary, by extracts of the follicular tissue, and by extracts of the chorion, but not by extracts of the corpus luteum. The corpus luteum of pregnancy inhibits ovulation, but administration of luteal extracts does not inhibit ovulation (Corner)

Various toxic effects have been observed from injections of ovarian extracts (for example disturbance of calcium and phosphorus metabolism) particularly in pregnant animals Seolovicy reports that corpus luteum and ovarian extracts administered subcutaneously to lactating animals cause increased secretion of milk and at the same time general deleterious effects leading to death of the animals These injections are said to be non toxic in non pregnant and non lactating animals This action of ovarian extract on the mammary gland was also noted by Ott and Scott

Mackenzie reported that it is absent from extracts of ovaries containing no corpus luteum The substance must therefore be a product of the latter organ This mammary gland action of corpus luteum is like that of pituitrin, not a true secretion of milk but the stimulation of the smooth muscle in the walls of the mammary alveoli thus expelling the milk that has already been formed (Schafer)

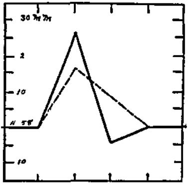

FIG 1 —COMPOSITE CURVES SHOWING BLOOD PRESSURE RESPONSES TO STANDARD DOSES OF NICOTINE The continuous line represents reactions before the broken line after castration of dog (Wheelon)

Itagaki a pupil of Schafer reports that extracts of the hilum (interstitial cells) of the ovary depress the tone and contractions of the uterus Extracts of the follicular tissue and the liquor folliculi itself, produce increased tone and stronger contractions of the uterus Whether these substances are artefacts or normal products assuming a role in life for example in the uterine cramps of painful menstruation is an important practical question that calls for speedy solution According to Sick corpus luteal tissue added to the food of rats tends to produce adiposity Fichera states that the enlargement of the hypophysis following spaying is prevented by ovarian feeding

Therapeutic Use of Ovarian Preparations—At present the use of ovarian preparations as organotherapeutic agents is confined to gynecology, and their detailed discussion properly belongs in special works on this subject But it is possible however that with increasing knowledge of the relations of these glands to other organs of internal secretion they acquire importance in connection with general internal medicine

The definite conditions where the ovarian organotherapy might prove useful are infantilism in girls and the menopause artificial and physiological, as these conditions are clearly due to ovarian hypofunction

Many writers report favorable results in menopause cases The attacks of giddiness trembling palpitation, flushings sweatings and other nervous and vasomotor disturbances are reported to be much reduced in number and severity or to have ceased entirely in some cases The best results are obtained in cases of postoperative menopause especially in young women Relapses are said to occur after stopping the treatment Many cases have been reported in which the results were negative, and in some of those with improvement suggestion may have been an important element The most judicial and convincing clinical contribution to ovarian therapy in recent years is that of Novak On the basis of his own extensive clinical experience as well as his critical analysis

of the literature, Novak concludes that, to date, clinical ovarian organotherapy is purely experimental, *that taking the natural history of hypo-ovarian disorders into consideration one cannot say as a proved fact that ovarian administration has had any beneficial effect apart from the element of suggestion.*

Excepting the menopause, practically all the disorders of sex life of women may be due to causes other than a primary ovarian deficiency, so that the use of ovarian preparations in all of these conditions is at present largely empirical, both because of the uncertainties of diagnosis and because of the uncertainty as to the kind of ovarian therapy indicated. As Marshall has aptly remarked, "it would seem unreasonable to expect to obtain uniform results from the indiscriminate uses of ovaries in different stages of cyclical activity, for example, ovaries with prominent follicles like those from animals in heat, or ovaries with corpora lutea like those of pregnant animals or ovaries in a state of relative quiescence like those of anestrous animals." And it must not be forgotten that ovaries of many of the lower animals also differ markedly from those of man, in accordance with the differences in the sex life. For that reason ovarian material from the apes should be given a thorough trial. Some of the conditions in which ovarian medication has been tried, with varying degrees of success, are infantilism, amenorrhea, dysmenorrhea, sterility, repeated abortion, hyperemesis gravidarum, toxemia of pregnancy, pruritus vulvæ, deficient milk secretion. Watson reports that he has rarely seen any good effects from ovarian extracts in any of these conditions.

In recent years, following the work and theories of Frankel, the corpus luteum, or extracts of this organ, has largely replaced the extract of the entire ovary in the therapy of female sex disorders. This is unfortunate, as Frankel's theory is, at least in part, untenable. From extensive studies on the guinea pig Leo Loeb concludes that the presence of a functionating corpus luteum is necessary for certain of the cyclic changes in the uterus, for other uterine changes the absence of the yellow body is necessary, while for still other phases of the cyclic uterine changes other ovarian structures (probably mature follicles rather than the so-called interstitial cells) are required. But, practically, it may make little difference, as it is not likely that any drug manufacturer is so careful that all ovarian stroma and follicular tissue are excluded from his luteal preparations.

Clinical experience, however, has not been uniform. Frankel reports more or less favorable results in disturbances ...ports t... menopause, etc., but the drug had no effect on dysmenorrhea, ...ously to... nenst... n, and the intoxications of pregnancy ... same tim...

Recently it has been especially recog... The ...
and scanty menstruation, and when ...lactat...
may be due to this insufficiency ... gland

strual flow, and to prevent nervous conditions accompanying their functional deficiency

Krusen states that in so called ovarian insufficiency improvement usually follows corpus luteum administration if persisted in for a long time Burnam reports good results from corpus luteum given by mouth in menopause, functional amenorrhea in young women sterility and repeated abortion Burnam states that corpus luteum does not induce menstruation in the complete absence of the ovaries This is contradicted by Donnereuther (one case, no control) This author using the corpus luteum of pregnant cows, reports uniformly good results in menopause, functional amenorrhea and dysmenorrhea sterility not due to infection or mechanical defects, hyperemesis in early pregnancy repeated abortion neurasthenic symptoms during menstruation etc Culbertson reports good results from corpus luteum feeding on the vasomotor disturbances of the menopause Other clinicians report negative or indifferent results from corpus luteum therapy in all of these conditions Dalche states that in dysmenorrhea long continued use of thyroid gives better results than preparations of the ovary In Frankel s hands corpus luteum gave results only in menopause cases Leighton states that a small number of cases of dysmenorrhea, presumably due to ovarian hypofunction, are improved by giving corpus luteum 15 to 20 grains per day, for a long time In some instances this medication caused gastro intestinal disorders, but no other untoward effect According to Climenko corpus luteum extracts do not act as hormones and cannot take the place of a functional corpus luteum He thinks these extracts may stimulate an intact but hypofunctioning corpus luteum

In view of the fact that so many physicians have reported good results from corpus luteum therapy in the *amenorrhea of adolescence* we were struck by the recent paper of Landsberg in which he claims to have cured seven cases of *menorrhagia of adolescence* by a corpus luteum preparation It would thus appear that the very opposite conditions amenorrhea and menorrhagia, are both controlled by the same agent, corpus luteum! It is probable that the luteal therapy has no causal relation to the improvement or cure of either condition as there is no evidence that the yellow body influences menstruation except directly through its inhibitory control of ovulation At any rate we must conclude that so far medical science has failed to reproduce (experimentally or clinically) by luteal extracts the effects produced by the intact corpus luteum The intact corpus luteum inhibits ovulation, luteal extracts do not

Causes for Failure of Ovarian Therapy—These are probably complex We may destroy or lose the ovarian hormones in the preparation of the substance as in the degreasing process of preparing the ovarian extracts or powder The hormones may be destroyed in the alimentary canal or fail to be absorbed There are indications, for example, that the gonad

hormones do not pass through the placenta Finally, it must ever be kept in mind that practically all the disorders of the sex life of women may have their initial cause outside of ovarian hypofunction It is well established that amenorrhea may come as a result of quantitative and qualitative undernutrition, anemia, chronic infection, hypothyroidism, and possibly from hypopituitarism This may seem to be an argument for polyglandular organotherapy in disorders of sex function in women But, because of the failure of ovarian therapy in frank or certain ovarian hypofunction, there seems to me no good reason for adding ovarian extract to thyroid extract in our endeavor to reestablish menstruation suppressed by myxedema

Methods of Preparation and Administration —The ovary (usually of the cow) has been administered by mouth in the fresh and dried state, and in the form of various extracts, both orally and subcutaneously At present it is most frequently fed in the form of the dried fat free powder, *in doses of 0 06 to 0 5 grm (1 to 8 grains) or more three or more* times a day As it sometimes causes disturbances of digestion, its use may be interrupted at times

The dried gland is frequently administered in the form of tablets, *the designation of the weights of the commercial tablets is as lacking* in uniformity as in the case of thyroid tablets

The dried powdered corpus luteum (also called 'lutein") has been administered in doses of ½ to 2 grains (0 03 to 0 12) or more, three times a day It has been used in the form of various extracts Maits used a sterile 1 per cent extract of the corpus luteum in normal saline solution injected subcutaneously in doses of 10 c c

No clinical progress can be expected from further use of commercial preparations until methods of chemical and physiological standardization of ovarian products have been worked out and applied

Summary

1 The ovaries produce several physiologically important substances or hormones, none of which have been isolated and chemically defined There is no reliable evidence that any or all of these hormones are present in any ovarian extract so far made for experimental or therapeutic pur poses The development and maintenance of the secondary sex characters of the female is clearly a function of the ovarian stroma and possibly the immature follicles The initiation of estruation or rutting is evi dently a function of the mature follicles primarily The corpus luteum is essential for the processes of the early stages of pregnancy It also retards the maturation of other graafian follicles thus preventing estrum, *menstruation*, and ovulation during pregnancy The ovarian hormones thus control, in part, the activity of the ovaries themselves, and the

specific sex functions of distant organs such as the uterus the placenta and the mammary glands

2 The menopause syndrome, natural and artificial is primarily due to absence of or hypofunction of the ovaries All other disorders of the sex life of women may be due to complications outside the ovaries Some of these complications involve other endocrine glands notably the thyroids possibly the hypophysis and the adrenals. In these conditions diagnosis is frequently uncertain, and, unle s the malady is clearly due to ovarian hypofunction, ovarian organotherapy cannot be expected to yield results

3 In the present state of ovarian physiology organotherapy of the natural and artificial menopause should be undertaken with the extract of the entire ovary rather than with corpus luteum preparations, as the role of the latter organ concerns some phases of the early tages of pregnancy and suppression of ovulation while the other ovarian tissues sustain the fundamental processes of sex life

THE FETUS AND THE PLACENTA

Chemical substances or hormones yielded by the growing fetus (and possibly by the placenta) to the maternal blood appear to control the hyperplasia of the mammary gland during pregnancy even to the point of actual initiation of the milk secretion (Lane Claypon and Starling Aschner) This is probably the normal mechanism, although there are cases on record of mammary hyperplasia and milk secretion in adult virgins and even in males But there is no practical therapeutic application of this fact, as there is no reliable evidence that feeding placenta or fetal extracts will improve the quality or quantity of milk in nursing mothers (Hammet and McNeile) or develop the breasts in cases where this may be desired for cosmetic reasons Aschner reports that placental extract causes ovarian hyperemia, uterine congestion and hyperplasia hence he suggests the use of placental extracts in amenorrhea and sterility Van Hoosen Cornell and Hammet have reported that daily feedings of dried placenta to mothers during the first few weeks of lactation lead to increased growth of the nursing infant They conclude from this that the placenta produces a growth stimulating hormone, and suggest that this hormone may be a factor in the growth of the fetus The results reported by Hammet, even if corroborated, may be due to dietary factors also found in other tissues

Summary

There is at present no reliable evidence that the placenta secretes a hormone or hormones having useful or important actions on the mother or the fetus actions that can be duplicated by feeding placenta *Hence there is as yet no placental organotherapy*

THE MAMMARY GLAND

The mammary gland is an organ found only in the highest group of vertebrates, *rudimentary in the male, and in the female active only for a* certain period after parturition It is not likely that an organ so limited in its distribution and activity has itself any important influence on the vital processes of the mammalian female The important problems in mammary gland physiology are the dietary and hormone mechanism of the gestation hyperplasia and the postpartum milk secretion

There is not much evidence that the mammary gland produces an internal secretion, beyond the fact that, in women, menstruation is usually in abeyance during the height of lactation, but in other mammals heat or estruation appears shortly after parturition There is, however, some evidence that it contains substances which have effects (probably not specific) upon metabolism Thus Hunt reports that, when mammary gland is fed to animals, it causes changes in metabolism analogous in certain respects to those caused by thyroid feeding

Complete removal of the mammary gland in the adult female is not known to produce any but psychic and cosmetic effects The complete removal of the mammary glands in young females is said to retard sexual maturity and the growth of the uterus (Scherbak) But such mutilated females become pregnant and give birth to young as under normal conditions *Nursing hastens the involution of the uterus (rat, guinea pig)* This effect is produced even after spaying (Kuramitsu and Loeb) This may be merely an effect of the increased metabolism in connection with the active lactation

Injections of mammary gland extracts are said to retard the development of the ovaries and the external genitalia (Schiffmann and Vystavel) According to Adler they inhibit heat and conception, and in gravid animals cause abortion

According to Osborne, Tunez and others, mammary gland extracts decrease uterine hemorrhages Several authors (Bell Fedoroff, Mekertschiants) report the cure of uterine fibromas and myomas by these injections! Sellheim proposes the removal of the mammary gland to cure eclampsia! Hammet guesses that stimulation of the breasts releases mammary hormones into the blood, hormones that cause contraction of the uterus! Healy and Kastle suggest that a mammary hormone is responsible for the initiation of labor!

Mackenzie claims that the mammary gland contains a true galactagogue or milk producing hormone This would be of great clinical importance, if true, but Gavin contradicts it squarely, and, in the light of Gaines' work, the results of Mackenzie are in all probability erroneous

There is no reliable evidence that the mammary gland is an endocrine

organ, or that feeding mammary gland substance produces any specific or useful effects in health or disease *Hence there is no rational or useful organotherapy of the mammary gland at present*

THE TESTES

Physiology —The testicles, at least of the higher vertebrates contain two distinct types of cellular elements having evidently different functions (1) the interstitial cells of Leydig and (2) the spermatogonia, which develop into spermatozoa The role of the spermatogonia and spermatozoa is clear, namely the fertilization of the female ovum This fertilization involves two factors on the part of the male element (1) a stimulus to development of the ovum and (2) a vehicle of paternal heredity In performing these functions the spermatozoa act, from the point of view of the male as an external secretion

Numerous attempts have been made to isolate the substances in the spermatozoa concerned in these two functions In the case of some of the lower animals various extracts of the sperm are reported to induce development in the ovum, but there is no evidence that the paternal hereditary factors can be conveyed to the ovum by bathing the ovum in sperm extract

The interstitial cells of Leydig vary greatly as regards relative abundance in the testes of different species They are quite abundant in man In embryonic development the interstitial cells antedate the spermatogonia In animals showing seasonal periodicity in sex activity the interstitial cells appear to be more abundant during sexual rest than during the period of rut (Tandler and Gross) The interstitial cells exhibit greater resistance to various agencies Exposure of the testicle to the X rays leads to degeneration and atrophy of the spermatogonia before that of the interstitial cells In testicle transplants, in the condition of cryptorchidism, and after ligation of the vas deferens the cells of Leydig persist apparently in normal condition long after atrophy of the spermatogonia But recent work of Moore on rats and guinea pigs seems to show that ligation of the vas does not always induce atrophy of the seminiferous tubules

Influence of Congenital Absence Atrophy or Extirpation of Testicles —The effects of castration have been known for a long time through its extensive practice in animal husbandry and on boys and men for religious and social purposes in various countries Removal of the testicles in the young vertebrate male has the following effects

1 It prevents the development of all the secondary male characters (penis prostate gland beard male larynx, male skeletal characters hin

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menopause in women There is no reliable evidence that castration shortens the span of life or measurably impairs the individual's physical and mental efficiency Senescence in the male is therefore not a direct consequence of hypofunction of the testicles but the result of age impairment of all the tissues

On the basis of extensive studies on the effects of gonadectomy in the rat Hatai concludes that "the partial removal of the sex glands does not produce any significant alterations in any of the ductless glands aside from a general tendency to a slight increase Apparently this increase in the remaining gland is sufficient to compensate for the functions of the lost gland"

The total removal of sex glands, however induces alterations in all the other glands particularly in the thymus and hypophysis The suprarenal glands show opposite reactions in the two sexes In the case of the males, the suprarenal glands show an increase of 1 per cent while in the female there is a 20 per cent reduction

The total removal of the sex glands tends to increase the resemblance between the two sexes or, in other words to reduce the differences in those secondary characters which, in the normal animal are modified according to sex."

Function of Interstitial Cells—The following facts seem to show that the development and maintenance of the sex life in the vertebrate male is primarily a function of the interstitial cells

1 In cryptorchidism there may be complete atrophy and absence of spermatozoa and spermatogonia, but, if the interstitial cells are present, sex structures and sex functions remain normal These males are of course sterile

2 After ligation of the vas deferens, the spermatogonia suffer gradual and finally complete atrophy but as long as the cells of Leydig are intact sex life remains unimpaired Extirpation of such modified testes brings on the usual sequelæ of castration. Steinach claims that ligation of the vas induces hypertrophy of the Leydig cells

3 Testicular transplants maintain sex life as long as sufficient quantity of the interstitial cells continues to live irrespective of the degeneration of the sperm producing elements, and extirpation of such partially degenerated grafts brings on the typical symptoms of castration

The control of the sex life of the male by the cells of Leydig is evidently a humoral one as a denervated testis and a testicular transplant in another organ and thus outside of its normal sensory nerve relations functions for a time like a normal testis except for fertility This is also indicated by the fact that men with complete transverse lesions of the spinal cord, provided the trauma is not great enough to cause marked

and feather colors, horns, etc) In some of the invertebrates the castration has no effect on the body male characters In species where horns are not a sex character, castration has no effect on the horn growth

2 It delays the ossification of the long bones, and the union of the sutures of the skull

3 It leads to certain changes in the endocrine glands, the most notable being the enlargement of the hypophysis, and the adrenal cortex, and the retarded involution of the thymus The growth of the thyroid is said to be diminished But Moore has recently reported that castration in the young guinea pig *decreases* the growth of the hypophysis, the adrenals, and the spleen, and causes *increase* in the size of the thyroid Evidently this aspect of gonad function requires further investigation

4 The rate of metabolism is somewhat lowered, with a tendency to adiposity, vasomotor irritability (sympathetic system) is said to be decreased

5 The most notable mental change in the castrated male is absence of the boldness, pugnacity, and viciousness of the normal male, particularly during the breeding season In this respect the castrated male may be said to resemble the child or the female This comparison must not be carried too far Hikmet and Regnault say of the eunuchs of Constantinople that "they are avaricious, stupid, credulous, illogical, obstinate, fanatical, fond of children and animals, faithful in their affections but lacking in courage" But the reader will admit that this characterization will fit many a man with intact and normal testicles

6 There is little or no development of the sex urge in its various manifestations

When the testes are removed in the adult male the most notable changes induced are

1 Sexual impotence and diminution or loss of sex urge
2 Tendency to atrophy of the secondary male characters
3 Lowered rate of metabolism and tendency to obesity

The striking specificity of the influence of the testes on organs is shown in the case of the growth of horns Horns are modified skin structures apparently identical in all mammals having these organs Nevertheless in species where the horns constitute a specific male character, castration prevents their development while in the species where the horns are common to both sexes, castration has no effect on their growth

Thus we see that atrophy or extirpation of the testes leads to impairment and final loss of all structures and functions specific for the sex life of the male, but it does not bring on any serious disturbance of other functions There are no sequelæ comparable to those of the artificial

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animals. Loewi states that giving testicular extracts to young capons induces development of the male characters Walker was unable to prevent the atrophy of the prostate in castrated dogs by injection of testes extracts Walker and Riddle have reported that administration of testicular extracts to female animals (chickens pigeons) tends to produce male characters and male behavior It has been demonstrated by Meisenheimer that in castrated male frogs the characteristic development of the forelegs at the breeding season can be induced by testes extracts

Clinical—The testes, variously prepared was used by the ancient Greeks and the Hindus as an aphrodisiac and tonic Its modern use in that direction dates back to Brown Séquard in 1889 who administered extracts of the testes to himself and thought he experienced a great augmentation of bodily and mental vigor Zoth and Pregl using the ergograph, report some evidence of increase in muscular work after subcutaneous injections of the extract Similar results would probably have followed the injection of any tissue extract In many of the reports of the action of the extract on normal persons the element of suggestion was not controlled

The work of Poehl and his associates with spermin was even more sensational than that of Brown Séquard Poehl regarded spermin is a general metabolic stimulant or catalyzer and reports good results from its use in the following maladies Asiatic cholera syphilis erysipelas, delirium tremens gas (CO) poisoning chloroform and ether poisoning impairment of heart and lungs optic atrophy hemiplegia, paralysis, catatonia, cholera hysteria, neurasthenia myelitis scurvy marasmus, skin diseases typhoid fever, toxic goiter, pulmonary tuberculosis diabetes mellitus, anemia and gout This is a good example of organotherapy running amuck! There is no evidence that any of these maladies are in any way related to hypofunction of the testes So far as we know there is no evidence that castration lowers the resistance to infection or otherwise produces conditions favorable to the above diseases And particularly in cases of toxic goiter where the destructive metabolism is increased to a degree not found in any other disease except high fevers any therapy which still further augments the metabolism is clearly contraindicated But others have recommended the use of testicle extracts in toxic goiter, diabetes, obesity, eczema, etc. (Jones, Friedlander Bauffe, Burghart)

Transplantation of the Testes—Transplantation of the testes appears to be only a temporary measure even under the most favorable conditions, as the graft is sooner or later completely absorbed, but as long as a sufficient amount of the tissue remains alive the graft is able to sustain sex life even when as in Nussbaum's experiment it is placed in the lymph sac. Wheelon and Shipley found that a testes transplant was not able to re-

mental and physical depression, from the beginning retain their inclination toward the female sex, although they can no longer experience the sensations due to erection and coitus

Relation of Interstitial Cells of Testes to Cortical Cells of Adrenals, Hypergenitalism—From the field of histology and organogenesis, evidence has been adduced to show that the cells of Leydig in the testes and the cells of the interrenal or the cortical system arise from the same embryological anlage This may be accepted as true, but it does not constitute a proof that in their adult differentiation the functions of these cells are identical or reciprocal Instances are also related in the literature of tumors (hyperactivity) of the adrenal cortex producing sexual precocity in boys This is significant, if true, and if there is no evidence of premature development of the testes themselves Tumors of the testicles may also induce sexual precocity However, it is clearly *established that no other gland in the body can assume the role of the* interstitial cells in sex life. After castration in a normal animal the other endocrine glands either remain normal or undergo some hypertrophy These hypertrophies, even in the case of the adrenal cortex, cannot be of compensatory nature, at least as regards the specific sex role of the testes, since they do not maintain sex life If the hypertrophies are compensatory it must be in relation to some general metabolic or detoxication function that the testes have in common with other endocrine glands

Chemistry of Testes—The nature of the process or the substance in the interstitial cells that sustains the male sex life remains unknown Poehl claims to have isolated a substance from the entire testicle, having the formula $C\,H_{14}N$ and called by him "spermin" He reports that this substance is the physiologically active constituent of testicular extracts, and, injected hypodermatically, it accelerates metabolism and acts as a general physiological tonic Dixon found an abundance of nucleoproteins, other products, organic bodies not affected by boiling, and inorganic salts in extracts of the testicles Hermeux reports the presence of lipase and amylase in the interstitial cells With the possible exception of Poehl's spermin, there appears to be nothing specific in these findings Similar substances are found in all organ extracts

From a series of very interesting experiments on male frogs, Nussbaum concludes that the testicular secretion acts primarily upon the nervous tissue as a tonic or a stimulus, and the augmented or altered activity of the nervous tissue, in turn, sustains the sex life This view is probably true in specific cases, but cannot be accepted as a complete statement of the situation

Clinical and Experimental Uses of Testes Extracts—*Experimental*—Bouin and Ancel report that injection of testicular extracts into castrated guinea pigs prevents the atrophy of the male characters According to the same authors this extract also accelerates the growth of the

tained Yet surgeons have reported successful testes grafts using testicles five days after extirpation from the donor

5 At present, the most that a testes graft can do even temporarily, is restoration of libido and copulation power with synchronous increase in metabolism Other alleged effects on mind and body are probably due to suggestion Fertility is not restored Testes grafts are therefore, at present, a *biological futility* a catering by the surgeon to the elements of sex degeneracy in our species

Summary

1 The specific sex characters and sex life of the vertebrate male are developed and sustained by hormones secreted by the testes In the case of the mammals there are indications that some of these hormones begin to function in early embryonic life The hormones that determine development to full sexual maturity are probably different from those that sustain sex life during full sexual maturity

2 Complete removal of the testes either in youth or after maturity prevents or abolishes sex life, but has no other significant or deleterious effect physical or mental, on the individual

3 The only fields for rational organotherapy of the male gonads are the comparatively rare cases of atrophy, disease, or accidental loss of the testes The rather meager experimental and clinical data on this point indicate that the administration of testicular extract by mouth or parenterally, does not sustain sex life It cannot of course, overcome sterility *On the whole organotherapy of the testes from present indications is very limited and of little importance*

THE PROSTATE GLAND

The prostate gland is a secondary male character undergoing atrophy on castration and varying in size and secretory activity with the activity or dormancy of the testes The prostate secretion mixes with the spermatozoa and forms a part of the seminal fluid This prostatic secretion may be of importance in maintaining the nutrition and activity of the sperm

In these days of active interest in hormones, suggestions of internal secretion functions have also been made for the prostate Macht reports that feeding prostate to tadpoles stimulates growth, and hastens metamorphosis But this may be a dietary factor rather than an index of hormones Feeding prostate gland to mammals has so far yielded no clear effects Macht was unable to demonstrate any impairment in mental ability and nervous coordination in prostatectomized rats. Reichel has described cells in the prostate gland similar to the Leydig cells in the

store the vasomotor irritability of castrated animals to its normal level, though there was some improvement.

Morris has reported an instance of a testicle transplant apparently stimulating a dormant testicular remnant so that it hypertrophied into an apparently normal testicle. The patient had lost most of the testicles at the age of thirteen in a complication of mumps The man, age twenty seven, at the time of the testicular transplantation, showed some effects of castration.

We have now a great body of data, experimental and clinical, on testicle transplantation (Steinach, Sand, Moore, Lespinasse) The scientific interest and biological significance of the problem is great. The clinical interest is concerned with the possibility of restoration of sexual potency with attendant physical and mental stimulation ("rejuvenation") in old men, the possibility of rejuvenation of partially atrophic testicles in younger men, and thus the restoration of male fertility, and the possibility of counteracting the alleged physical and mental lethargy and anatomic stigmata that follow the loss of the testes in boys. The clinical work in testes transplantation has been further stimulated by the universal failure to counteract testes deficiency (interstitial cells) by feeding testes preparations in any form. The following facts seem established

1 If adequate surgical technic is used a fairly high percentage of takes" is secured both from autotestes and heterotestes transplants, whether the graft is placed in the scrotum, under the skin, or in the peritoneal cavity

2 Practically in every case only the cells of Leydig survive, and the length of survival is variable In rats and guinea pigs testes grafts may live at least six months. The most favorable clinical reports indicate a survival of from a few months to two years, but these cases have not been checked up by histological study of the graft. We have only the patient's own word for his sex potency, and this is not always reliable At present there is no evidence that the testes graft can live through the normal period of male adole cence Why a testes graft once adequately vascularized undergoes atrophy within such a short time is not known

3 There is no reliable evidence that testes transplanted from goats or monkeys to man ever become vascularized and survive The reliable evidence is all to the contrary At present this type of surgery, when done for pay with definite promises of results is quackery, and does the honest medical profession much harm. In this business the surgeon is the monkey, and the patient is the goat.

4 The question of how long a human testicle will survive after it is removed from the body and used for grafting is not settled Most mammalian organs, particularly glands, die within a few hours after excision, probably from asphyxia, even when asepsis and low temperatures are main

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THE PROSTATE GLAND

The prostate gland is a secondary male character undergoing atrophy on castration and varying in size and secretory activity with the activity or dormancy of the testes The prostate secretion mixes with the spermatozoa and forms a part of the seminal fluid. This prostatic secretion may be of importance in maintaining the nutrition and activity of the sperm

In these days of active interest in hormones suggestions of internal secretion functions have also been made for the prostate Macht reports that feeding prostate to tadpoles stimulates growth and hastens metamorphosis. But this may be a dietary factor rather than an index of hormones Feeding prostate gland to mammals has so far yielded no clear effects Macht was unable to demonstrate any impairment in mental ability and nervous coordination in prostatectomized rats. Reichel has described cells in the prostate gland similar to the Leydig cells in the

testes Kandaleon has reported hypertrophy of the mammary glands in two seventy year-old men, following prostatectomy This is at least not a frequent result of prostatectomy, as this is a common operation in modern surgery, and we are aware of no reports similar to that of Kandaleon

During the active sex life of the male, the prostate gland depends on the testes, nevertheless, there is frequently a hypertrophy of the prostate in old men when the testes functions are definitely on the decline This is an actual contradiction, since the prostatic enlargement in old men is glandular

SUMMARY

1 There is, at present, no reliable evidence that the prostate furnishes an internal secretion, since prostatectomy induces no demonstrable defects, prostate feeding is without influence, at least in mammals, and nothing even remotely resembling a hormone has so far been found in this gland

2 The use of prostate material in organotherapy is therefore without any basis, at present The pseudomedical literature furnishes, of course, testimonials of cures of a variety of ailments from the growing pains of childhood to postoperative melancholia, and the drug houses furnish prostate extract Under these conditions, it is up to the doctor to furnish the antidote of common sense

THE PINEAL BODY

The pineal body is an evagination of the embryonic neural tube It is composed of ependymal cells in a framework of neuroglia and connective tissue According to comparative anatomy, the pineal body represents the vestigeal remnant of a median eye, perhaps functional in some species of reptiles, but its histological structure, at least in youth the effects of pineal tumors in man, as well as some of the experimental physiology of the organ in birds and mammals, indicate that it may be a gland of some importance, at least during pre adolescence Its physiological importance is, however, not yet clearly established

In man the pineal body continues to grow until the age of seven to eight years, when atrophy or involution sets in, so that in the adult the pineal body is made up mostly of connective tissue cells and the so-called "brain sand" The average weight of the gland in man is 0 22 gram It takes 25,000 pineal glands of calves to make up one pound of dried gland substance (McCord) The size and structure of the pineal body appears to be identical in males and females

Jordan has noted the great abundance of the blood supply to the organ The presence of sympathetic nerve fibers in the pineal body has also been asserted (Cajal)

Injections of Pineal Extracts—The intravenous injections of extracts of the pineal gland have revealed no action of specific physiological importance at least for the circulation (Jordan and Lyster Horrax, McCord) In large doses, pineal extracts lower the blood pressure but this is not specific

McCord states that subcutaneous injections of sterile pineal gland (young calves) into young guinea pigs three times weekly has a marked stimulating action on growth

Extirpation of the Pineal Body—According to Biedl Exner and Boese, and Dandy, extirpation of the organ in adult dogs or in rabbits (young or adult) produces no demonstrable effects Because of the location of the gland, most of the operated animals die within twenty four hours of hemorrhage, brain injury and shock But the few that survive the operation trauma are said to remain normal Both Sarteschi and Foa report very different results from pinealectomy in young chicks rabbits, and rats According to Foa the operation has little or no effect in females, except a temporary retardation of growth In the males the extirpation of the gland leads to precocious sexual maturity This acceleration of sexual maturity was also observed by Sarteschi in operated male pups and rabbits Horrax reported a slight acceleration of the growth of the testes in pinealectomized guinea pigs No demonstrable effects were produced in the operated females The most important and conclusive work in pineal gland extirpation is that recently reported by Dandy on young dogs Dandy extirpated the pineal body in pups (male and female) ten days to three weeks old and observed their body growth sex life, and mental behavior for eight to fifteen months after the operation In no case did he find sexual precocity or indolence adiposity or emaciation, somatic or mental precocity or retardation Dandy concludes that the pineal body is not essential to life and seems to have no influence on the animals well being at any age

Feeding Pineal Material—McCord reported that feeding pineal glands to young animals (guinea pigs) accelerates growth and hastens sexual maturity, both in males and females There was no tendency to gigantism The pineal fed animals simply attain adult stature at an earlier period According to McCord, these effects are most striking when the pineal organ obtained from young animal (calves) is fed Hoskins and also Sisson and Finney on the other hand obtained negative results from feeding pineal material to rats McCord and Allen reported a peculiar contraction of the skin pigment in tadpoles fed with pineal material They propose this reaction as a quantitative test of pineal extracts Pineal substance seems to hasten reproduction in some unicellular organisms

Dana and Berkeley claim that feeding or injecting pineal gland to 'backward' children improved their mentality although growth of the

body was not accelerated Goddard and Cornell extended these tests to a large number of backward children The results were negative.

Pineal Tumors—Tumors of the pineal body in the young have frequently been associated with acceleration of growth (mental and physical, including precocious adolescence) The syndrome is designated "macrogenitosomia præcox" Cachexia is present, probably due to brain injuries

The interpretation of the body changes in the case of pineal tumors in the sense of hypo activity or hyperactivity of the gland is very uncertain, especially in view of the contradictory results of animal experiments McCord reporting that pineal feeding produces the identical results described by Foa and Sarteschi as following complete extirpation of the pineal body

There is at present no rational or useful pineal organotherapy The contradictory effects reported from work on animals and the uncertainty of pineal deficiency in man must be cleared up before we are justified in trying pineal organotherapy in the clinics, even experimentally At present there is no reliable evidence that the pineal body is a gland, or a gland of any importance The bodily changes in cases of pineal tumors may be due to involvement of the midbrain.

THE THYMUS

Physiology—The thymus develops in the embryo from the epithelium of the third branchial pouch Its origin is thus similar to that of the thyroid and the parathyroid We have seen that accessory thyroids and parathyroids are frequently found embedded in the thymus tissue The thymus is primarily an organ of fetal and preadolescent life, as in normal men and animals it undergoes involution at puberty, and is finally replaced by connective tissue, lymphoid tissue, and fat But it is reported that the thymus of birds does not undergo involution at sexual maturity (Soli) Jansen reports 'accidental involution" of the thymus in starvation and malnutrition This is probably not a true involution but merely the great reduction in weight suffered by this organ in fasting The relative size of the thymus is greatest shortly after birth

The thymus contains several types of cells The outer or cortical portion of the gland is made up of lymphoid cells According to Danschakoff, Hammar and others, these small cells of the thymus cortex differentiate into the various forms of leukocytes of the blood and lymph Hoskins has pointed out the parallel between the decreasing percentage of weight of the thymus in relation to body weight, and the decrease in lymphocytes in the blood from birth to adolescence The central portion, or medulla, is composed of a few lymphoid cells and the peculiar "corpuscles of

Hassall," composed of nests of epithelial cells. The function of the Hassall's bodies is not known

The specific role of the thymus is still very obscure and most of the investigators question whether it should be classed with the endocrine glands The organ is not necessary for life The facts definitely established are the involution of the organ at puberty and the delay of this involution by castration

Henderson states that early castration accelerates the growth of the thymus and prolongs or delays involution Involution of the thymus occurred especially rapidly in animals used for breeding purposes On the

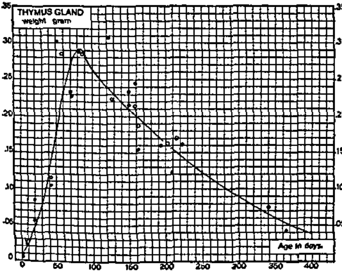

Fig 22.—Chart Showing the Weight of the Thymus of the Albino Rat According to Age. The observed weights are represented by 2 9 males and 07 females. (Hatai)

other hand Paton states that removal of the thymus in sexually immature animals led to a rapid growth of the testicles

From such experiments and observations it has been concluded that the thymus exerts an inhibitory action upon the development of the testes and that the development of the testes has an accelerating effect upon the involution of the thymus Paton concludes from more recent experiments that thymus and testes both exercise an influence on the growth of the sexually immature animal the removal of both retards growth This has not been established for the ovaries and thymus of the female After removal of one the other can compensate for its loss, and in doing so may undergo a more rapid growth or, in the case of the thymus may persist for a longer period Further evidence of a relation between the

thymus and sex glands has been sought in the fact that the ovaries are sometimes enlarged in status lymphaticus (Bartel and Herrmann)

The relation of the thymus to growth was studied by Basch and others in young animals from which the thymus was removed Such animals are said to show delayed growth and diminished intelligence The changes in the bones were especially marked, these showed deficient ossification Basch, and Paton also, reported that the peripheral nervous system showed an increased excitability, as determined by galvanic stimulation, and Paton suggests that there is a close relation of the thymus and the parathyroid functions

Klose and also Klose and Vogt state that if the thymus is removed from puppies about ten days after birth, there is a latent period of two to four weeks, followed by a condition of adiposity for two to three months, then cachexia and a condition resembling idiocy, and death in "thymic coma" after three to fourteen months They say that extirpation of the thymus in infants is followed by similar results They consider the gland to be an important organ in early life They also state that the bones of animals deprived of the thymus have only about half the normal amount of calcium They consider the bone and other changes to be due to acid *intoxication, and that one of the functions of the thymus is to inhibit the* formation of or to neutralize an excessive formation of acids, probably nucleic acid Essentially similar results were reported by Matti

But Nordmann states the removal of the thymus shortly after birth in dogs has no effect on growth or other physical conditions Hammar found that thymectomy in frogs produced no demonstrable effects, and Allen has shown that thymectomy in amphibian tadpoles is without influence on growth and metamorphosis Morgulis and Gies report that the calcium content of the bones and teeth of thymectomized rats remained the same as in the normal controls, hence, they contend that the thymus has no definite necessary influence on bone growth More recently extensive and careful studies on thymectomy in rats and young dogs have been reported by Pappenheimer, Park, and Park and McClure The results were negative

The experimental results from thymectomy are, therefore, very contradictory Koenig reports a resection of the thymus in a nine-months old child, followed by severe and prolonged rachitis There is no evidence, however, that the thymus resection was the cause of the rachitis

The thymus is often found persistent or enlarged in cases of Graves disease, especially in the severer forms Capelle and Bayer believe that an internal secretion of the thymus aggravates the symptoms, especially the cardiac symptoms of the disease They, as well as Pribram, report improvement from thymectomy Bircher stated that the implantation into animals of a pathological thymus caused symptoms of Graves disease, such as tachycardia and tremors

Rachford believes that the thymus produces an internal secretion affecting nutritional processes especially in fetal life and early childhood, he believes that status lymphaticus is due to an excessive activity of the thymus Friedlander stated that exposure of the thymus to Roentgen rays causes diminution in the size of the spleen and lymph nodes in status lymphaticus Nordmann thinks that some cases of toxic goiter are due to abnormal functioning (hyperplasia) of the thymus But feeding thymus to certain rabbits is without effect (Carlson)

Gudernatsch and Laufberger found that feeding thymus accelerates growth of frog tadpoles This has been denied or ascribed to the food as such (Uhlenhuth) Shimizu claims to have produced a thymotoxic serum (thymolysis), the injection of which produces the same results as thymectomy Ott and Scott report that thymus extracts have a galactagogue action This is erroneous Uhlenhuth reports that feeding calves thymus to salamander tadpoles induces tetany and inhibits metamorphosis He interprets this as establishing an internal secretion (toxic) by the thymus, this secretion being destroyed by the parathyroids This interpretation seems at present far fetched Subcutaneous injections of thymus substance into young rabbits seem to produce no specific effects (Downs and Eddy)

Pathology —The primary role of the thymus in the disease syndromes frequently associated with an enlarged thymus (status lymphaticus thymic death, toxic goiter), is still unknown There is no clear evidence that hyperfunction of the thymus is an etiologic factor although the apparent beneficial effects of X ray and surgery of the thymus may be so interpreted Mors thymica is not due to mechanical interference with circulation and respiration (Hammar) *Stammering* has been ascribed to hyperthymism (Browning) Bergstrand has described two cases of simultaneous thymic and parathyroid hyperplasia

Therapeutic Uses of Thymus Extracts —Thymus has been administered in many diseases (gout simple and toxic goiter, marasmus, retarded growth, infantilism, rheumatism arthritis, chlorosis acromegalia, Addison's disease, etc) Mikulicz reports favorable results from thymus feeding in simple and toxic goiter Uncertain or negative results from the administration of thymus in goiter (simple and toxic) were reported by Mackenzie, White Parker and many others But thymus feeding has no effects on experimental hypothyroidism (rabbits) where all conditions can be controlled

Nathan administered thymus to rachitic children in doses of from two to four five-grain tablets (each tablet apparently containing dry gland equivalent to five grains of the fresh gland) three times a day for long periods. In one hundred and eighty six cases treated, practically all improved When the thymus is conscientiously taken for a long period, *and the patient is otherwise judiciously handled* marked improvement, if not a

tracts The injection of the spleen extract has no influence on the resistance of the red cells to hemolysis. In some cases the administration of the spleen extract induced a slight and temporary leukocytosis, but this was also noted in the case of extracts of other organs Krumbhaar and Musser noted that the constant increase in red cells in the peripheral circulation after injection of spleen, in view of the tendency to anemia following splenectomy, suggests that "the spleen may normally exert a stimulating effect upon the formation of red cells in the bone marrow"

Feeding spleen or spleen extracts to animals, even over a long period, has no effect on the blood picture, and fails to prevent or diminish the anemia following splenectomy (Krumbhaar and Musser) This is a fact of great practical importance for possible spleen organotherapy in man, where repeated subcutaneous or intraperitoneal administration of a crude tissue extract is, of course, out of the question We see that *on the basis of well controlled animal experiments we cannot hope to control spleen deficiency or induce specific spleen functions by feeding spleen or spleen preparations*

Flexner has reported various toxic effects from spleen extract administration

Hypofunction or Dysfunction of Spleen in Splenic Anemia Hemolytic Jaundice and Hanot s Cirrhosis—There is some destruction of erythrocytes in the normal spleen, and possibly some degree of control by the spleen of red marrow, blood plasma, and erythrocytes so that the rate of erythrocyte production and hemolysis strike a balance in the normal animal In splenic anemia and hemolytic jaundice there is usually enlargement of the spleen, a decrease of resistance of the erythrocytes to hemolysis and an actual increased rate of erythrocyte destruction, as shown by the output of urobilinogen, urobilin, and iron in the feces McKelvie and Rosenbloom report a case of hemolytic jaundice and splenomegaly with the erythrocytes showing a decreased resistance to hypotonic laking The suggestion is made that this may be due to a decrease in the cholesterol content of the blood Robertson states that in pernicious anemia the erythrocytes of the splenic vein show less resistance to laking agents than those of the general circulation Extracts of the normal spleen have, however, no hemolytic action *in vitro* (Krumbhaar and Musser) This is also true of spleen extracts from pernicious anemia patients (Robertson) Extirpation of the spleen in splenic anemia appears to restore such patients to normal health, either through the absence of the actual hemolysis taking place in the spleen, or to some increased resistance in the erythrocytes to laking agents in the blood itself

After an examination of all the cases so far reported Miller concludes that "splenectomy is undoubtedly curative" Gerdes does not appear to be so sure of this But the improvement following splenectomy

shows clearly that the hyperfunction or dysfunction of the spleen is the primary cause of this type of anemia

The Spleen in Pernicious Anemia—The relation of the spleen function to pernicious anemia is less definitely established Most observers agree that splenectomy in pernicious anemia usually induces a temporary stimulation of the blood forming organs, and hence a transient improvement of the anemic condition but 'in no case can it be said that the splenectomy produces a cure of the disease (Krumbhaar) Blood transfusion has a similar stimulating action, but less marked and somewhat more transitory (McClure Lee Minot and Vincent) There is then no evidence that the spleen functions are primarily concerned in pernicious anemia

There is no satisfactory explanation of the opposite effects on the blood of splenectomy in normal persons and animals (*temporary anemia*) and in patients with pernicious anemia (*temporary improvement of the blood*)

Therapeutic Uses of Spleen and Spleen Extracts—The use of spleen extracts in constipation and intestinal stasis as a specific stimulant to gastro intestinal movements (Zuelzer) is referred to in the section on Duodenal Mucosa.

Spleen extracts have also been used in anemia and chlorosis in malaria in menorrhagia and in hemophilia No reliance can be placed on the favorable results sometimes noted in these maladies in view of recent work on the relation of spleen to anemia and the further fact that spleen and spleen extracts given by mouth have no specific action on the organism The anemias that are benefited by organic iron preparations will naturally, show improvement on spleen therapy as the spleen is rich in iron But this is drug or food therapy, not organotherapy as this action is not specific for the spleen

The most strikingly irrational use of any organ or organ extract in therapeutics seems to be that of spleen extract in tuberculosis Harrower and others have advocated and claimed to have proved that feeding spleen is a *specific* in tuberculosis! There is no basis for such therapy of tuberculosis either in the physiology and pathology of the spleen, in the biology of the tubercle bacillus or in the natural history of tubercular infections As a matter of fact Lewis and Margot state that splenectomy in mice increases the resistance to tuberculosis while feeding spleen has the opposite effect.

Summary

There is at present no evidence that the spleen secretes or stores hormones or that hypofunction of the spleen causes disease hence there is no rational or useful organotherapy of the spleen.

THE GASTRIC AND DUODENAL MUCOSA

Secretins—It is well established that acids or acid chyme in the duodenum is a stimulus to the secretion of pancreatic juice and bile Bayliss and Starling macerated duodenojejunal mucosa in 0 4 per cent hydrochloric acid, neutralized the mixture, and filtered A few cubic centimeters of the filtrate injected into a vein invariably produced secretion of pancreatic juice The substance in the extract stimulating the pancreas was called 'secretin" The secretin has since been prepared by other methods, and from a variety of plant and animal tissues. It is, thus, not specific for the duodenojejunal mucosa It has not been prepared in pure state All secretin preparations seem to have vasodilator actions. Popielski attributed the action on the pancreas to the vasodilatation This is probably not the primary or essential factor Luckhardt has shown that the 'secretin" of Bayliss and Starling is probably an artefact or drug rather than a physiologic agent, as this secretin on hypodermatic injection stimulates the pancreas and the gastric glands, while acid in the duodenum stimulates the pancreas promptly and the stomach not at all, or after a latent period of thirty to sixty minutes Furthermore, prolonged action of acid in the duodenum finally fails to stimulate the pancreas. This is not due to fatigue of the pancreas itself, nor to exhaustion of the duodenal mucosa, for this mucosa on acid extraction yields as much 'secretin" as the resting mucosa. It is therefore clear that if there is a hormone or 'secretin" mechanism connecting the pancreas and the duodenum, this hormone (secretin) has not yet been extracted from the duodenal mucosa The simplest explanation of the stimulation of the pancreas by acids in the duodenum would be a local nervous reflex, but that this does not account for it completely seems to be shown by the denervated intestinal loop experiments of Bayliss and Starling, as well as by the even more crucial transfusion experiments (Wertheimer, Henriquez and Hallion), and of cross circulation (Fleig, Matuso)

To the extent that the secretin passes into the lumen of the gut it is a wasted secretion and is quickly destroyed by trypsin and by pepsin hydrochloric acid digestion, and, even in the absence of these digestive ferments, secretin is not absorbed in active form from any part of the gut Giving secretin by mouth is therefore without effect on the activity of the pancreas and the liver Subcutaneous injections of secretin are also practically without effects In consequence of the instability of secretin the commercial preparations of secretin so far placed on the market (secretogen, duodenin, also the secretin of Beveridge) contain, as a rule, no prosecretin or active secretin (Carlson, Lebensohn, and Pearlman)

Secretin has not yet been prepared in pure form It represents at present a mixture of substances, probably including cholin Repeated

intravenous injections of secretin are therefore highly toxic producing collapse (Starling)

Secretin Organotherapy —It is obvious that a rational and useful secretin therapy demands these two fundamental condition (1) *Secretin must be a normal or physiological substance and deficiency of secretin in the duodenal mucosa must be an important factor in the etiology of the disease* (2) *Secretin must be able to influence the pancreas and the liver when given by mouth for it is not safe to introduce it repeatedly into the veins of human beings* Neither of these two conditions has been estab-

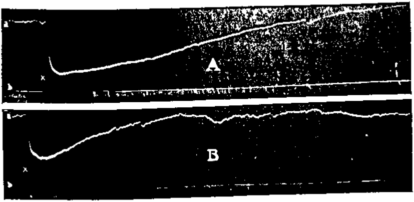

FIG 3 —TRACINGS SHOWING PRACTICALLY COMPLETE DESTRUCTION OF SECRETIN BY THE GASTRIC JUICE. Dog under light ether anesthesia cannula in the pancreatic duct a carotid blood pressure b record of flow of pancreatic juice in drops Time 2[illegible] minutes Tracing A intravenous injection of 10 cubic centimeters secretin (prepared fresh from dog's duodenal mucosa) at x Tracing B intravenous injection (at x) of 10 cubic centimeters of the same secretin as in Tracing A after being digested in normal human gastric juice at 37 C for [illegible] hours. (Carlson Lebensohn and Pearlman)

lished Despite this secretin, or alleged secretin has been used in the therapy of a variety of diseases

Diabetes Mellitus —Moore Edie and Abram were the first to suggest a therapeutic value for secretin, having obtained favorable results with secretin administration in diabetes They argued that the internal secretion of the pancreas may be stimulated by secretin and that some cases of diabetes may be due to lack of this necessary excitant. Owing to the importance of the question, their announcement was followed quickly by numerous investigations by other observers.

Previously, Spriggs, at the suggestion of Starling, had tried intravenous injections of secretin free from depressor substance in a diabetic patient, and had obtained negative results Moore Edie and Abram gave their secretin by mouth over long periods Of the five cases cited in

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In 1908, Zuelzer proposed, on the basis of badly controlled animal experiments the novel theory that there is a specific gastro-intestinal motor hormone, elaborated in the intestinal mucosa during digestion, absorbed into the blood and stored in the spleen Hence, the spleen was held to contain more of this alleged hormone than any of the other organs It was claimed that an extract of spleen and intestinal mucosa (hormonal) on intravenous or intramuscular injection produces normal intestinal peristalsis in man and animals without any injurious side effects The extract was tried for a time especially in Germany, in cases of chronic constipation, and postoperative intestinal stasis It was soon found that intravenous injections of this extract in patients may cause shock, collapse and sudden death And the more carefully controlled investigations of Dittler and Mohr Sabatowski Schlagenweit and others showed that intramuscular injections of the extract have little or no action on gastrointestinal motility, while the intravenous injections produce the general toxic symptoms characteristic of all tissue extract Hence there is no specific or physiological motor hormone in the duodenal and spleen extracts

After careful perusal of the entire 'hormonal' literature we are impressed with the uniformly favorable results first reported by Zuelzer and a host of other clinicians in two important case, namely, chronic constipation and postoperative intestinal stasis These results were undoubtedly due to suggestion and dictated by uncritical enthusiasm, faith and hope in a new remedy When crucial judgment returned, 'hormonal' was speedily found not only wanting but dangerous The 'hormonal' therapy had no basis in physiology or pathology It was not based on well-controlled experiments on animals So after a brief popularity with the credulous clinician it passed naturally to the therapeutic bone yard 'Hormonal' cannot do anything with gastro intestinal motility that cannot be accomplished, and with greater safety by such drugs as pituitrin pilocarpin, or eserin

In a recent series of investigations, Le Heux has advanced the theory that cholin in the wall of the gut constitutes the motor hormone for gastro-intestinal peristalsis This view is accepted by Magnus But cholin is a constituent or cleavage product of the phosphatids of all animal tissues Cholin in the blood is increased in case of degenerating nervous tissue, but there is no evidence that this is accompanied by intestinal hyperperistalsis Kuhlwein has shown specifically that the intestinal stasis during and following anesthesia is not accompanied by a decrease of cholin in the intestinal wall

At present it is neither safe nor expedient to use a toxic substance like cholin hypodermatically to control motor paralysis of the gut

Other Possible Hormone Functions of Intestinal Mucosa —The work of Draper and of Whipple and his collaborators on duodenal extirpation

their first paper, two were negative The third was that of a man aged twenty five, who received daily 30 c.c of secretin after a latent period of three weeks, the sugar suddenly fell, and after four months the urine was sugar free Six months later a relapse occurred with the development of phthisis and death The other two patients were a boy aged seven and a girl aged nine whose urine in from three to five weeks became sugar free, during secretin treatment, in spite of severe diabetes. One of the e pa tients later relapsed Bambridge and Beddard gave secretin a thorough trial in three cases with negative results, and are disposed to attribute the results of Moore to dieting Dakin and Ran om cited one case, ecretin being given for twelve weeks, with negative results, Foster, nine cases, all negative Charles, three cases, all negative Moore, Edie and Abram, in a later paper, report a large number of cases tried with the majority of results negative, though in some cases an improvement in the digestion, and in certain cases an increase of weight was noted

One method of testing the basis of Moore s theory would be by ex amining the prosecretin content of the intestine in diabetes Bainbridge and Beddard found, in the paper referred to, that from five of the six cases of diabetes examined postmortem, little or no secretin could be prepared, but in a subsequent report of seven cases they found only one in which the secretin obtained was scanty The failure to obtain secretin in some cases they claim is probably due to the rapid postmortem degenera tion of diabetic tissue Evans, in Starling's laboratory, stated that in dogs made recently diabetic by total pancreatectomy, but little secretin could be obtained Hedon and Lisbonne and Pemberton and Sweet, report, on the contrary, that the duodenum of diabetic dogs is rich in prosecretin Bainbridge and Beddard, working on a diabetic cat, likewise found prosecretin to be present in normal quantity

Digestive Disturbances—Enriquez has proposed that deficiency of secretin is a factor in intestinal indigestion and in constipation This is pure guess Beveridge reports the use of secretin in pyloric stenosis, pan creatic insufficiency, cirrhosis of the liver, colonic stasis, in gastro-enteros tomy and short-circuiting of the intestines Harrower advocated the use of secretin for a large number of maladies

Alleged Gastro intestinal Motor Hormone of Mucosa Hormonal , Cholin—Heidenhain showed more than twenty five years ago that intra venous injections of tissue extracts cause a temporary inte tinal peristalsis, defecation vomiting, etc, probably due to asphyxia from the greatly lowered blood pressure besides a number of other untoward symptoms In 1904, Henriquez and Hallion showed that by treatment of strips of gut with Ringer's solution or distilled water a substance may be extracted which stimulates contractions in another intestinal strip

Similar results were observed when the extract was injected into normal intact animals. This stimulating action is prevented by atropin

Summary

1 The substances "gastrin and secretin are drugs not physiological mechanisms or hormones They are ineffective when administered *per os* and cannot with safety be given parenterally

2 The gastric and duodenal mucosa may produce hormones that specifically regulate the activity of the pancrea the gastric glands and intestinal motility These hypothetical hormones have not yet been obtained in *extracts of these organs nor has it been shown that deficiency* of these hormones produces a disease

3 *We have therefore no rational or useful organotherapy of the gastro-intestinal mucosa.*

THE BLOOD

Blood Transfusion—The normal blood contains all the substances (nutrients, enzymes, hormones immune bodies etc) necessary for the proper functions of all the organs so far as these are exchanges between the tissues Theoretically it ought to be possible to administer all hormones to a patient by the transfusion of normal blood but experiments have shown that the hormones of the thyroid the pancreas, the adrenal, the parathyroid are present in the normal blood in such infinitesimal traces or are so quickly destroyed and used up that blood transfusion in cases of hormone deficiency has proved of no practical value Another reason for the failure of transfusion as a general hormone therapy is the difficulty of transferring enough of the normal blood to the patient, without previously draining the patient of the greater part of his own blood, and without endangering the donor The 500 to 600 c.c. usually transferred in blood transfusion of adults is too small a percentage of the total blood

Considering blood as a tissue or organ, *blood transfusion is virtually organ transplantation.* The blood is the ideal organ for transplantation from the aspect of surgical technic as there are no nervous and vascular connections to be considered, and in compatible bloods no destructive enzymes to be eliminated But from the physiological aspect we can hope for less permanent results from transplantation of blood than in the case of any other organ The equilibrium of the blood both as to corpuscles and plasma constituents is a dynamic, not a static one and depends on the activity of the other organs The effects of blood transfusion are, therefore, necessarily temporary, and the most satisfactory results are obtained in case of temporary need, as in *hemorrhage carbon monoxid poisoning etc*

and duodenal obstruction has suggested hormone functions of the duodenal mucosa other than those concerned with secretin and enterokinase Matthews claims that extirpation of the upper part of the duodenum in the dog invariably leads to death within three days, hence, he concludes that the duodenum is as necessary for life as the adrenals or the parathyroids, presumably through hormone function. But others have demonstrated that animals live indefinitely after duodenal extirpation (Minkowski, Dragstedt, Moorehead, Mann) Draper reports that feeding duodenal mucosa to dogs with duodenal obstruction or a closed duodenal loop lengthens the life of the animal somewhat, but fails to prevent death The experiments by Draper are not convincing Whipple reports the secretion or production of a toxic substance (protein split product) in closed intestinal loop and successful immunization of dogs against this toxin Dragstedt and his coworkers have demonstrated that the toxins of intestinal obstruction or closed intestinal loops are developed by the putrefactive bacteria acting on the food and secretion proteins in the gut. *The experimental work so far has yielded nothing in the way of hints of useful duodenal mucosa organotherapy of intestinal stasis and intestinal obstruction.*

The Gastric Mucosa, Gastrin—Shortly after the work of Bayliss and Starling on pancreatic secretion, Elkins, by analogous experiments on the stomach, developed the theory that acids in the food, or the acid of the gastric juice acting on the mucosa of the pyloric end of the stomach, produce or liberate a specific secretagogue ("gastrin") in the blood, which activates the fundic glands. It has since been shown by a number of investigators that an active "gastrin" can be prepared by acid extractions not only from the gastric mucosa, but from the mucosa of the entire alimentary tract, from the liver, the thyroid, various plant tissues etc "Gastrin" is not specific since it stimulates both the gastric glands and the pancreas It has no effect when given by mouth "Gastrin" is evidently an artefact, not a physiological mechanism. Koch, Luckhardt and Keeton have shown that it is similar to but not identical with histamin and pilocarpin

The experimental work on the "gastrins" has led a drug manufacturer to put gastric mucosa preparations ("gastron") on the market buttressed by unproved if not impossible, claims. The "gastrins" may some day be so purified that they may be injected hypodermatically in man, without injury, to increase gastric secretion But this is drug action, not organotherapy Given by mouth, gastric mucosa or gastrin preparations are without effect except when given in such large quantities that the dose practically amounts to a serving of soup The doctor who uses such preparations cheats the patient and deceives himself, unless he uses them as vehicles for suggestion in which case a pill or a capsule containing an equally harmless but less expensive stuff will do as well

a few cubic centimeters of the extract are injected subcutaneously into an adult person It has also been alleged that leukocytic extracts increase the immunity reaction, and aid the action of specific serums, antitoxins, and vaccines There is no evidence for this

Action of Leukocytic Extracts—The action of these extracts in infections is probably not specific It is well known that the injection of any foreign protein or nucleoprotein produces in most cases a temporary fever and leukocytosis To the extent that these two reactions are of value in infectious diseases, leukocytic extracts other organ extracts or still better, simple proteins may have some effect But this is drug action, not organotherapy

The important role in immunity (phagocytosis production of immune bodies) ascribed to the leukocytes by Metchnikoff is probably responsible for the great attention given to leukocytic extracts in infectious diseases. The leukocytes are not important elements in the fixation of antigens and production of immune bodies (Hektoen and Carlson)

Hemoglobin Feeding—The feeding of hemoglobin in various anemias is not organotherapy There is no evidence that giving hemoglobin by mouth or parenterally stimulates the bone marrow or prolongs the life of the erythrocytes except as this may be done by any other organic iron compound

Lymph gland Therapy—On the basis of incompetent experiments (hemodynamic action following intravenous injection of extracts of the lymph glands) Marfori has postulated a hormone (lymphoganglinc) production by the lymph glands After reviewing the entire literature on the subject Vincent concludes that there is not the slightest reason for believing that the lymph glands carry out any endocrine function'

SUMMARY

There is at present no organotherapy of the blood of the individual blood constituents or of the lymph glands

THE KIDNEY

The *theory that the kidneys produce a physiologically important internal secretion*, in addition to their excretory function, proposed by Brown Sequard and d Arsonval in 1893 has been shown repeatedly to be without foundation (Bradford Suner Vincent and Sheen Kirsner Bunker and Grabfield) but it still finds some adherents (Itakura) It has been claimed that ligation of the ureters does not produce the same effects on the animal as extirpation of the kidneys and that the removal of the greater part of the kidney substance accelerates metabolism apart

Blood transfusion has also been tried, with no significant results, in various infections, with the idea of transfusing immune bodies and active phagocytes to the patient It has been tried in *hemophilia purpura hemorrhagica* etc But the most extensive transfusion therapy so far developed is that of the various *anemias* Clinical and experimental experience appear to agree that blood transfusion stimulates temporarily the blood forming organs of the patient or the recipient, even in cases of pernicious anemia, unless the cachexia approaches that of a moribund condition The transfusion is, therefore, of value as a temporary palliative measure, not so much in virtue of the quantity of normal blood transferred as in the fact that this blood actually stimulates the patient s own blood forming organs to greater activity In cases where the anemia appears to be due primarily to too rapid destruction of erythrocytes, we may expect blood transfusion to be of less benefit

Physiology and pathology give us no basis for expecting, and clinical experience has not shown, that anemia, except that due to actual mechanical loss of blood is cured by transfusion, especially where the condition is hereditary or partakes of the nature of malignancy

Therapeutic Uses of Leukocytic Extracts—Hiss and also Hiss and Zinsser, beginning in 1908, reported that intraperitoneal or subcutaneous injections of extracts of leukocytes in animals, and subcutaneous injections of the extract in human patients, protect against many infections (pneumococcus staphylococcus, streptococcus, meningococcus, typhoid, dysentery and cholera), and in patients hastens the recovery from these infections Zinsser, McCoy and Chapin later reported a similar protective action of leukocytic extract against experimental bubonic plague Floyd and Lucas and also Lambert report good results from leukocytic extracts in pneumonia and erysipelas On the other hand, Alexander observed no favorable results in any infection Williams and Youland stated recently that leukocytic extracts have no effect on the temperature, the leukocyte count, the condition of the patients, or the course of the disease in lobar pneumonia Youland obtained practically negative results with the extracts of experimentally induced, acute infections in animals, thus contradicting the original observations of Hiss and Zinsser

Archibald and Moore report that injections of leukocytic extracts produce a temporary leukocytosis in normal animals and normal persons as well as in patients with infectious diseases They claim to have obtained good results, and report one case each of lobar pneumonia, cellulitis, puerperal sepsis, empyema, and erysipelas The cases reported prove nothing definite as to the value of the extract injections

Archibald and Moore ascribe the favorable action of leukocytic extracts to the stimulation of leukocytosis Manewaring supports the view of a direct bactericidal action of the extract Such bactericidal action can be demonstrated *in vitro* but it is too slight to be of any significance when

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vanced by European clinicians Good results are reported of course Jauregg and Bayer (*Lehrbuch der Organotherapie*) listed fourteen organotherapeutic liver preparations on the market Eleven of these were 'made in Germany'!

There is at present no rational or useful organotherapy of the liver and because *of the nature of the liver functions there is little or no* hope for the future in this direction But biochemical research may produce from the liver substances of biological and clinical importance in the way of drug actions

The recent work of Mann and others on extirpation of the liver indicates that the depression and death of the animal following loss of the liver is accompanied by extreme hypoglycemia The depression can be temporarily controlled by intravenous injection of *glucose* but the animal *dies* despite the glucose administration The cause of this hypoglycemia is not known The condition is not improved by liver extract administration But Hooper has shown that feeding liver can partly control the digestive disturbance following the complete elimination of the bile from the digestive tract in dogs

THERAPEUTIC USES OF OTHER ORGAN EXTRACTS

Brain and Spinal Cord—The treatment of epilepsy amentia, dementia præcox, mania, melancholia chorea tetanus hydrophobia etc., with extracts of nervous tissue is, in the light of our present knowledge less rational than the principles and practices of Mrs Eddy The literature on this therapy is abundant, contradictory and worthless. This is not saying that the nervous tissues produce or store no hormones or that interesting and useful drugs may not be prepared from these tissues But these things will never be established by indiscriminate feeding of dried brain to patients Perhaps we would make greater progress if the manufacturers could be induced to use the brains of horses instead of asses and sheep for their raw material and the finished product was taken by the doctor instead of given to the patient.

Bone Marrow—The red marrow of the bones is an essential factor in the production of red corpuscles and probably in the formation of many immune bodies But there is no evidence that feeding or injections of bone-marrow extracts is of any practical value in bone-marrow diseases

Tumors—Rational basis for the treatment of malignant growths with tumor extracts has been sought in the principles of vaccination and the 'protective ferments of Abderhalden. The results are unreliable or negative (Schubert, Bauer Lotzel and Wissler)

from or in the absence of uremia None of these claims has been substantiated

Itakura has recently advanced the novel view that the kidneys regulate the concentration of the sugar in the blood by an internal secretion This is unlikely, in view of the absence of primary renal involvement in diabetes, and the absence of hyperglycemia or reduced power to oxidize sugar in nephritis, except as due to uremia

Practically all the therapeutic uses of kidney extracts have been related to conditions of impairment of the excretory functions of the kidney Capitain, Donovan, Formanck and Eiselt, Renaut and others have reported the cure of nephritis and uremia by feeding kidney or subcutaneous injections of kidney extracts Others report negative or injurious effects (Lewandowsky, Senator) Kidney extracts have no specific diuretic action but kidney extracts for kidney organotherapy are on the market Jauregg and Bayer listed (1914) seven German and one French commercial preparations And here is a sample of the American clinical evidence for the efficiency of dried kidney substance in nephritis "The woman was five months pregnant, the urine showed a low specific gravity, about 1 per cent albumin, and other indications of renal embarrassment She was given *renal compound* (dried kidney and pancreas) *After its use for two months together with a regulated diet and rest the urine showed a normal specific gravity and no albumin* I cannot help but feel that we owe a good deal to organotherapy" (Harrower) [a]

In the light of our present knowledge of kidney functions and kidney pathology the treatment of uremia and nephritis by kidney extracts is useless and possibly injurious

THE LIVER

The liver plays a very complex part in the animal economy, external secretion (bile), detoxication (ammonia, amino-acids, hemoglobin, poisons, etc), internal secretion (glycogen, fibrinogen, antithrombin, immune bodies, etc.), desaturation of the fats, storage of vitamins, etc. So far as we know, all these processes depend from moment to moment on the living hepatic cells, and, as far as we know, there is *stored up* no substance of the nature of a hormone in the liver cells Hence, there is no rational basis for liver organotherapy Nevertheless extracts of the liver have been administered (by mouth or subcutaneously) in cirrhosis, diabetes, Banti's disease, hemoptysis, purpura epistaxis, hematemesis, metrorrhagia, prurigo, urticaria, snake bite, and other affections! It appears that most of this irrational and certainly useless therapy has been ad

[a] The italics are mine —A J C

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Muscle.—Meat is a good food for most people in health and for some people in disease. *But meat extracts are of no value as organotherapeutic agents.*

Lung, Parotid Gland, Tonsils, Lymph Glands, Retina, Iris, Nasal Mucous Membrane, Etc.—Why complete the list? Lung, parotid gland, tonsils, lymph glands, retina, iris, nasal mucous membrane, etc., have been used, *in modern medicine*, to cure diseases of these tissues. We are afraid this chapter furnishes an argument against evolution in medicine. It would be rare humor—if we were not dealing with human ills, and with a profession standing for intelligence and honesty, in opposition to the quacks.

Summary

The sum total of established facts after thirty years of clinical and experimental work in organotherapy are few and quickly stated.

But a treatise on the general principles of organotherapy involves to-day, in a large measure, the disagreeable and thankless task of clearing away worthless and misleading rubbish. We believe that the reader who has had the interest and diligence to follow us through this chapter will agree to this proposition, and we have endeavored to do it on the basis of clinical and experimental facts and biological reasoning.

In the greater task of pointing out new lines of possible advance and control, we have endeavored to steer a middle course between the Scylla of therapeutic nihilism, and the Charybdis of therapeutic credulity.

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NOTE Therapeutic agents appear in black face type as **Balneology**. Subject other than treat t p ar i plain capital as ACROMEGALY. All headings are alphabet zed and the relation of the sub-headings shown by indentation.

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